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A new Worthington high duty pumping engine for the water-works of Marlborough, Mass., was tested on May 13. The engine has 36-in. low and 18-in. high-pressure cylinders, 14-in. plungers and 2.5%-in. stroke. According to the contract it must deliver 2,500,000 gallons of water in 24 hours against a head, including piston and suction lift, of 408 ft., while the duty guaranteed was 105,000,000 ft.-lbs. per 1,000 lbs. of dry steam.

The following are the principal results of the test:

	Gallons.
Ten hours pumpage by plunger displacement.	1,176,240
Ten hours pumpage by weir measurement....	1,162,504
Slip, 1.2%, or.....	15,321
Rate of pumping, 24 hours, weir measurement.	2,790,096
Piston speed, 130.24 ft. per minute.	
	Foot-pounds.
Duty from 100 lbs. of coal consumed.....	109,165,000
Duty on 1,000 lbs. of water evaporated from temperature of injection.....	121,303,000

The boiler is a 60-in. tubular boiler, with 15-ft. tubes, built by the Cunningham Iron Works, South Boston.

The following are the principal results of the boiler test:

	Pounds.
Coal consumed per sq. ft. grate surface.....	14.28
Water evaporated per sq. ft. heating surface....	32.58
Net evaporation per pound of coal from temperature of injection.....	8.72
Do., from actual temperature of feed.....	10.37

Steel ties have been used for some years on the Mexican Ry., with very satisfactory results, and the company has recently advertised in England for proposals for 48,000 steel ties and 105,600 steel keys for the same. During last year, 24 miles of the line were reballasted with stone, and the operation of laying steel rails throughout the whole line was finally completed. Arrangements have been made for laying heavy rails and steel ties the whole distance of the mountain ascent from Paso del Macho to Boca del Monte, a distance of 60 miles, and also for providing seven powerful Fairlie engines, similar to those now in use on the road.

A speed-record of one mile in 32 seconds, is said to have been made by the New York Central engine No. 999, May 11, while hauling the Empire State Express. The same engine made a mile in 35 seconds on May 3, as already noted. These records mean rates of 102 and 112½ miles per hour; but the maintenance of that speed for one second and for 3,600 seconds are very different things. Engine No. 999 is, however, probably the most powerful machine of its type ever built, as will be seen by the full details elsewhere given in this issue.

An arrangement to facilitate the ventilation of, and the carrying off of smoke and steam from the interior of trainsheds is proposed by George C. Crocker, of Boston. It is more particularly applicable to low roofs of moderate span, and consists of a continuous ventilator or chimney, over the middle of each track, running the whole length of the track. Whatever may be the desired height of the ceiling or roof, this ventilator extends down nearly to the top of the smoke-stack. In the ventilator are occasional partitions, some of which extend up to the openings in the ventilator, while other extend to the top of the ventilator. The truss members and water conductors cross through the ventilator.

The most serious railway accident of the week was a crossing collision at Western Ave. and W. 18th St., Chicago, May 14. The accident occurred at the crossing of the Chicago, Burlington & Quincy R. R., and the Pittsburg, Cincinnati, Chicago & St. Louis R. R. A freight train of the former road was standing on the crossing, and an eastbound passenger train was passing on the next track, when a northbound freight train of the latter road ran into the standing freight train, throwing two cars from the track against the passenger train, smashing one of the cars and killing a man who was standing on the platform. The engineman of the freight train stated that he was running his train about five miles an hour, and when about 1,000 ft. from the crossing saw that the gate was closed. He shut off steam and applied the air brake, but it failed to operate. Then he reversed the engine, but as he had 15 loaded cars he could not stop in time to prevent the accident. This is another instance in which the air brake is made the scapegoat in a case of probable carelessness.

A locomotive boiler explosion occurred May 13, at Lebanon, Pa., on the Philadelphia & Reading R. R., by which two persons were killed and five injured.

A bridge carrying the Pittsburg, Cincinnati, Chicago & St. Louis R. R., over the canal near Frazersburg, O., was knocked down by a derailed car May 16, and the engine and 15 cars went into the canal; one man was killed. The falsework of one of the spans of a bridge being built across the Nooksack River at Everson, Wash., by the San Francisco Bridge Co. was carried away by flood May 8, and the bridge damaged. The trestle built to replace the Central Vermont R. R. bridge recently washed out at Middlebury, Vt., and noted below, gave way under a freight train May 11. Some of the dents had been damaged by a car that had gone down with the bridge, floating against them.

The failure of the Central Vermont R. R. bridge over Otter Creek near Middlebury, Vt., on May 5, was noted last week, and we are indebted to Mr. F. W. Baldwin, General Superintendent, for the following particulars: The bridge was 236 ft. long over all, and about 25 ft. above the bed of river. It had two spans of 118 ft. over all, both of which were wrecked. The bridge was of wood, with iron truss rods, and was about 30 years old. It is supposed that the middle pier was undermined or weakened by high water, and both spans went down with the middle pier, the bridge being a complete wreck, but nobody was killed or injured. The middle pier was composed of hard pine crib work on piling. Up to May 13 the water had not gone down sufficiently to enable the cause of the pier giving way to be determined. The water had been very high for some time, with considerable flood wood coming down, and it is supposed that the pier had become undermined or damaged by the high water, or possibly the piling of the pier weakened under the water by the ice when it went out early in the spring. The structure was a through Howe truss bridge, which was thoroughly overhauled and strengthened last fall by additional stringers, plates, braces and truss rods, so that it was regarded as being very strong, and in the breaking up of the material the timber proved to be in very good condition.

The harbor defense ram "Katahdin," built by the Bath Iron Works, Bath, Me., to the designs of Admiral Ammen, U. S. N., for the new navy, is 251 ft. long over all, 41 ft. 6 ins. beam on the water line and 22 ft. deep, with a draft of 15 ft. and a displacement of 2,150 tons. She is propelled by twin screws and triple expansion engines, and the estimated speed is 17 knots. The vessel will attack with the ram only, but is fitted with four 6-pdr. rapid fire guns to resist torpedo boat attacks.

The immigration into the United States for the three months ending Sept. 30, 1892, was 166,356, as compared with 188,460 for the same period in 1891. Out of this first number 114,749 were steerage passengers, and 48,336 were women. Of the total 123,201 classed as immigrants, 96,247 landed at the port of New York, and about 8,000 each are credited to the ports of Baltimore, Boston and Philadelphia. Of those landing at New York, 32,431 registered as citizens returning from abroad, and 5,707 as aliens not intending to remain in the United States. There were 51,607 cabin passengers landed in the same three months. As to the nationality of immigrants, Austria-Hungary sent 13,906; Germany, 25,704; Russia, 12,073; Poland, 7,900; Sweden, 9,000; and the United Kingdom, 27,363. Of the 119,634 European immigrants, 18,253 were under 15 years of age, and 93,778 were between 15 and 40 years old; the remainder were over 40 years old.

A Lake Ontario-Georgian Bay ship canal project is said to be again under consideration by New York capitalists, the only name mentioned being that of the chief promoter, Mr. E. A. Macdonald, of Toronto. The scheme, which is very old as far as the ship canal is concerned, includes the construction of a 60-mile aqueduct to supply Toronto with water. The total estimated cost is over $50,000,000.

A Niagara Falls electric power distribution syndicate has been formed, with a capital of $4,000,000, to build and equip a transmission line between Niagara Falls and Albany, to distribute the power generated by the new plant at the first named place. The Niagara Falls Power Co., under the bill signed by Governor Flower on April 25, can transmit light, heat or power practically to any point in New York state.

A ship canal 12 miles long is proposed between Lake Erie and Lake St. Clair. This waterway would shorten the distance 110 miles as compared with the Detroit route, and Mr. C. O. Wyatt, a civil engineer, of Duluth, is reported to be in Ottawa, seeking a charter for its construction.

Brick pavements in St. Louis, Mo., are condemned in a report by the Commissioner of Streets, Mr. M. J. Murphy. He says they have been tried since 1878, and they have failed to give good results. Under a traffic which averaged 1,000 commercial teams in 12 hours, the brick on a 6-in. concrete base lasted 3 years. In another case, with brick on a sand base, and with 3,500 commercial teams in 12 hours, the pavement lasted only 9 months. The tonnage in the first case was 105, and in the second case 295 tons per foot of wheelway. The commissioner quotes Philadelphia, Newark, O., Washington, Kansas City and Columbus, O., as being dissatisfied with their experience with brick pavements and as having ceased to use them. He admits that under light traffic and with a uniform material, and a density that will exclude water, good results are attainable.

The Brooklyn Bridge will have been opened to traffic ten years on May 24, and previous to 1883 about 15 years had been consumed in construction. The use of the bridge has constantly increased, until now it is used by about 40,000,000 persons annually, and the new terminals now under construction will add much to its present capacity.

The Broadway cable-road in this city is at last completed. On the second trial trip of the cable-cars, the round trip, from Broadway and 50th St. to the Battery and return, was made in 1 hr. 40 m. It is expected that in about two weeks 180 cable-cars will be in operation on the line.

The Nyassa Co. has been organized in England to develop the resources of the province of Mozambique in east Africa, comprising about 100,000 sq. miles. The town of Pemba will be the starting point of the railway to Lake Nyassa, which railway crosses an extensive coalfield, said to yield a semi-bituminous coal suitable for steamship fuel.

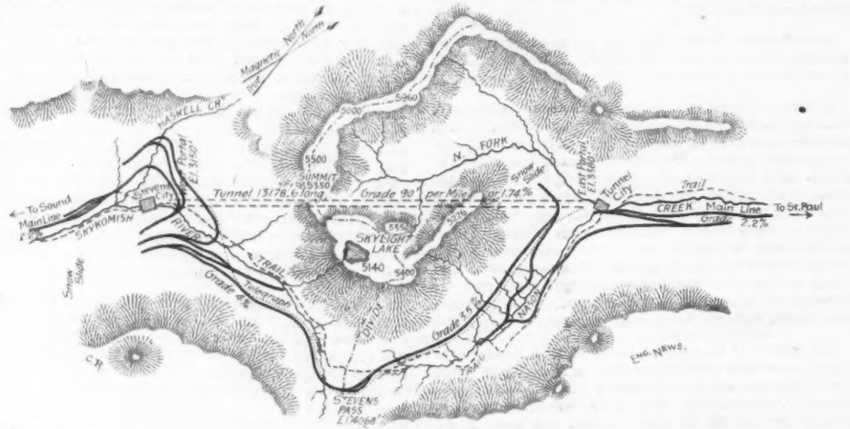
A steamship, 800 ft. long, to be called the "Gigantic," is to be built by the White Star Line, according to a London news item. The New York representatives of the line disclaim any knowledge of the new ship, but admit that the company must soon build a ship that will eclipse those of rival companies in speed and accommodations. The speed of the proposed "Gigantic" is to be 27 knots, and Harian & Wolff are mentioned as the builders.

The Manhattan Life Insurance Co.'s building, at 64-68 Broadway, New York, has been commenced, and work is progressing rapidly upon the foundations. As before mentioned, this foundation will be carried through the quicksand formation down to rock on steel caissons, about 11 ft. high and 10 ft. in diameter to 20 ft. square, with the load to be imposed. The sand is blown out in the manner usual with the application of the pneumatic process to foundations for bridges. The contractors for this interesting part of the work are Messrs. Charles Sooysmith & Co., of New York. When completed, this building will be 16 stories high, with the top of the main roof 242 ft. above the level of Broadway. The top of the flagstaff on the tower will be 347 ft above the pavement. The building is to be finished by May 1, 1894.

THE GREAT NORTHERN RAILWAY TUNNEL THROUGH THE CASCADE MTS.

We show in the accompanying sketch map the general plan of the switchback by which the Pacific Extension of the Great Northern Ry. temporarily crosses the summit of the Cascade Mts., and also the location of the tunnel by which it will be replaced. The Pacific Extension of the Great Northern Ry. runs from Pacific junction near Havre, Mont., to Everett, Wash., on Puget Sound, a distance of 817 miles, and was built in 1890-92 to give the company an independent line to the Pacific coast. In selecting a route for the line the engineers were limited to a maximum grade of 2%, which, notwithstanding the mountainous character of the country, was attained without incurring especial difficulties in construction except at the crossing of the Cascade Mts. in Washington. Here it was found necessary to construct a tunnel 2.49 miles long. Owing to the inaccessibility of the location it was practically impossible to begin the construction of the tunnel until the railway had been completed to that point, which was late last fall, and in order to accommodate the through traffic during the building of the tunnel it was decided to run a switchback line across the summit.

The map shows the location of the tunnel, the switchback now in use, and the nature of the mountain section at the point where both are located. Beginning on the 2.2% grade of the main line approach to the east portal of the tunnel the line reaches the summit at Stevens Pass by three switches, and with a maximum grade of 3½%. Its



SKETCH MAP OF SWITCHBACK AND PROPOSED CASCADE MOUNTAIN TUNNEL ON THE GREAT NORTHERN RY.

highest elevation is 4,055 ft., where it passes through the Pass in a 13-ft. cut. The descent on the west side of the summit is more difficult, the maximum grade being 4%. The Skykomish River also has its source on this side of the mountains and had to be crossed three times.

The route of the tunnel which will replace the switchback is a straight line from canyon to canyon through the base of the mountains. The west portal, which will be at Stevens City, is 3,150 ft. above sea level, and the east portal, at Tunnel City, is 3,380 ft. From portal to portal is 13,178.63 ft., or a distance of a fraction less than 2½ miles. The tunnel will therefore slope toward the west with a grade of 90 ft. to the mile, there being 230 ft. difference between the levels of the east and west portals. The land for some distance around is still unsurveyed and the location of the tunnel, according to government marks, has not been accurately determined. But it is in King Co., close to the Snohomish line, in the north row of sections of township 26 N., range 10 E., of the Willamette meridian.

The direction of the tunnel is a few degrees south of west and meets the head of a canyon at both ends, in which the grade approaches are 2.2% or 116 ft. to the mile. It will pass beneath the highest elevation about a mile from the west portal, where the summit is 5,350 ft. above the sea level. A short distance south and east of the summit, at an elevation of 5,140 ft., is Skylight Lake, which is fed by the melting snow from the surrounding ridges.

The tunnel will be a single track 16 ft. wide and 23 ft. high, and is estimated to cost $2,000,000. It will be lined with brick, but other material will be utilized where found more expedient. The construction will be according to the most approved methods and will probably take about two years. As trains have to be broken up in order to be handled on the switchback, the work will be advanced with all possible rapidity to save the loss of time, especially since the road's principal competitor, the Northern Pacific, has completed its tunnel (Eng. News, Oct. 3, 10 and 17, 1891) and abandoned the switchback, and it is probable that contracts will soon be let.

NOTES FROM RECENT WATER-WORKS REPORTS.

The last report of the water department of Concord, N. H., contains a description of the new high service works, which include a 2,000,000 gallon pumping station. A view of the building, presented in the report, shows it to be a pleasing structure, architecturally. Mr. V. C. Hastings is superintendent. At Manchester, N. H., about a mile of cement-lined water mains was replaced with cast iron in 1892. There were at the close of the year 21.1 miles of cement-lined and 41.7 miles of cast iron pipe. Mr. Chas. K. Walker is superintendent.

The water-works recently built by the water supply district of Foxborough, Mass., are described by the engineer, Mr. F. L. Fuller, of Boston, in the recently issued report of the water commissioners and Mr. Ezra Clark is president. The Lowell report contains an account by Mr. Geo. Bowers, City Engineer, of progress on the driven well plant, for which $100,000 has been appropriated.

An unprecedented development of algae occurred on the filter beds of the water-works at Poughkeepsie, N. Y., in July, and continued until October, 1892. The algae grew upon the sand surface of the beds and in from 10 to 12 days, and in one instance in seven days, completly stopped filtration until removed. Beneath the suspended platforms used for cleaning the filter beds, which float in the water when not in use, no algae developed, nor did they in the covered intermediate and clear water basins. Water is pumped from the Hudson River. Mr. Chas. E. Fowler is superintendent.

Biological examinations of the water of the Mohawk River at Schenectady, N. Y., the source of the city's water supply, were recently made by Prof. Chas. C. Brown, of Union College, assisted by Prof. J. H. Staller. A search for a new supply is recommended by Professor Brown in his report, the water giving evidence of pollution and showing an excessive number of bacteria, for a domestic water supply.

When meters were introduced at Atlanta, Ga., in 1885, the water consumption was nearly 6,000,000 gallons per day. This was soon reduced to about 1,500,000 gallons per day and for the year 1892, seven years later, the average daily consumption was only 2,530,000 gallons per day.

The reduction in pumpage and coal consumption, caused by the introduction of meters in 1885, was so great that the year's supply of coal, bought on the usual basis in March, 1885, lasted until July, 1887.

The alum used in the Hyatt filters at Atlanta during the year 1892 was at the average rate of 0.77 grain per gallon of water filtered, the total amount of alum used during the year having been 123,580 lbs. Several half-tone views of portions of the works for a new supply now under construction, are given in the Atlanta report for 1892. Mr. W. G. Richards is superintendent.

The last report of the water-works of Madison, Wis., contains a map on a scale of 10 chains to the inch, showing the existing water mains by sizes, and also the location of hydrants, valves and wells, and the pressure at each hydrant. Mr. John B. Heim is superintendent.

PUBLIC LANDS OF THE UNITED STATES.

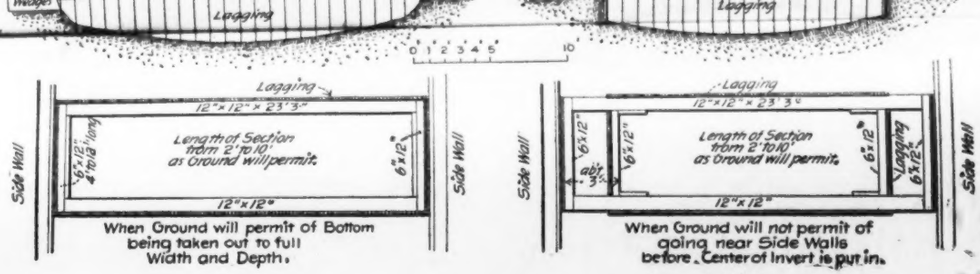
From the annual report of the Commissioner of the General Land Office the following matter is compiled relating to the area of the United States: The thirteen original states covered an area of 318,752 sq. miles; while the present area of the 44 states, 5 territories and the District of Columbia and Oklahama, is 3,580,805 sq. miles, or 2,291,615,347 acres. In this last estimate Alaska, with 577,390 sq. miles, is included among the territories and in itself nearly doubles the area of the colonial states.

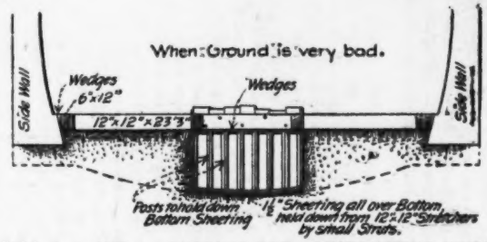
The Commissioner says that from the data available it is impossible to state whether the figures he has used for the thirteen original states and the six states admitted between 1791 and 1862 embrace both land and water surface. In the states and territories when the public land survey is completed or in progress the surface of meandering waters is alone excluded, the surface of all lakes and non-meandering streams being included in the area given.

Few people realize that out of the total area of the United States on June 30, 1892, 811,520,237 acres, or nearly 40% of the whole area of the country under our control still remained unsurveyed. In this unsurveyed portion Alaska is credited with 369,592,600 acres, or by far the greater part. But California shows 28,356,169 acres of unappropriated land; Oregon has nearly 20,000,000 acres; Nevada has over 38,000,000; North and South Dakota combined has about the same; Montana has 70,200,000 acres; Idaho has nearly 44,000,000; Utah has 39,000,000; Washington has 22,400,000, and Arizona, 57,600,000 acres. Of course, this land lies generally in the far west, mountainous and practically unsettled portions of our territory; but even states like Iowa, Minnesota, Louisiana and Nebraska still contain millions of unmeasured acres.

From five to eight million acres of land per year

FIG. 6.—SECTION SHOWING METHOD OF INJECTING CEMENT GROUT.


Lagging
Length of Section from 2' to 10' as Ground will permit.
12"×12"×23'3"
6"×12"
Side Wall
When Ground will permit of Bottom being taken out to full Width and Depth.
When Ground will not permit of going near Side Walls before Center of Invert is put in.


When Ground is very bad.
Wedges
6"×12"
12"×12"×23'3"
Side Wall
Posts to hold down Bottom Sheeting
1½" Sheeting all over Bottom, held down from 12"×12" Stretchers by small Struts.

FIGS. 2, 3, AND 4.—CAISSONS FOR CONSTRUCTING INVERT.

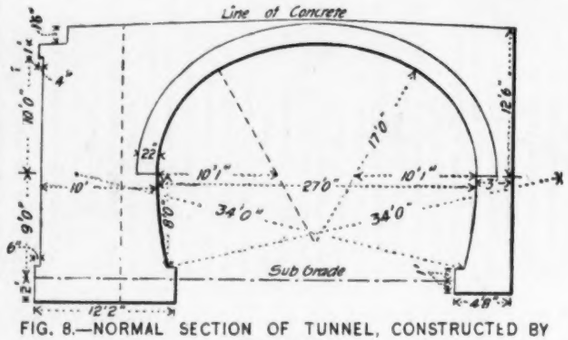


FIG. 8.—NORMAL SECTION OF TUNNEL, CONSTRUCTED BY OPEN CUT.

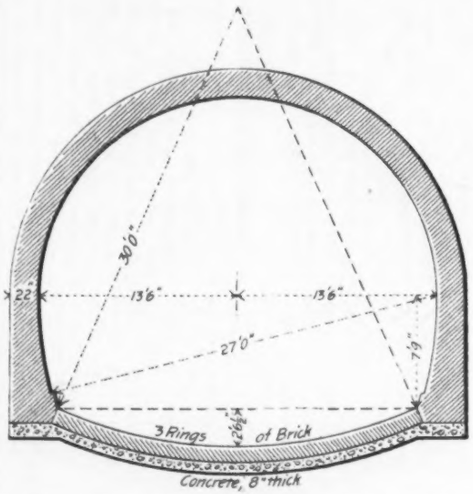


FIG 5.—NORMAL SECTION OF TUNNEL WITH INVERT.

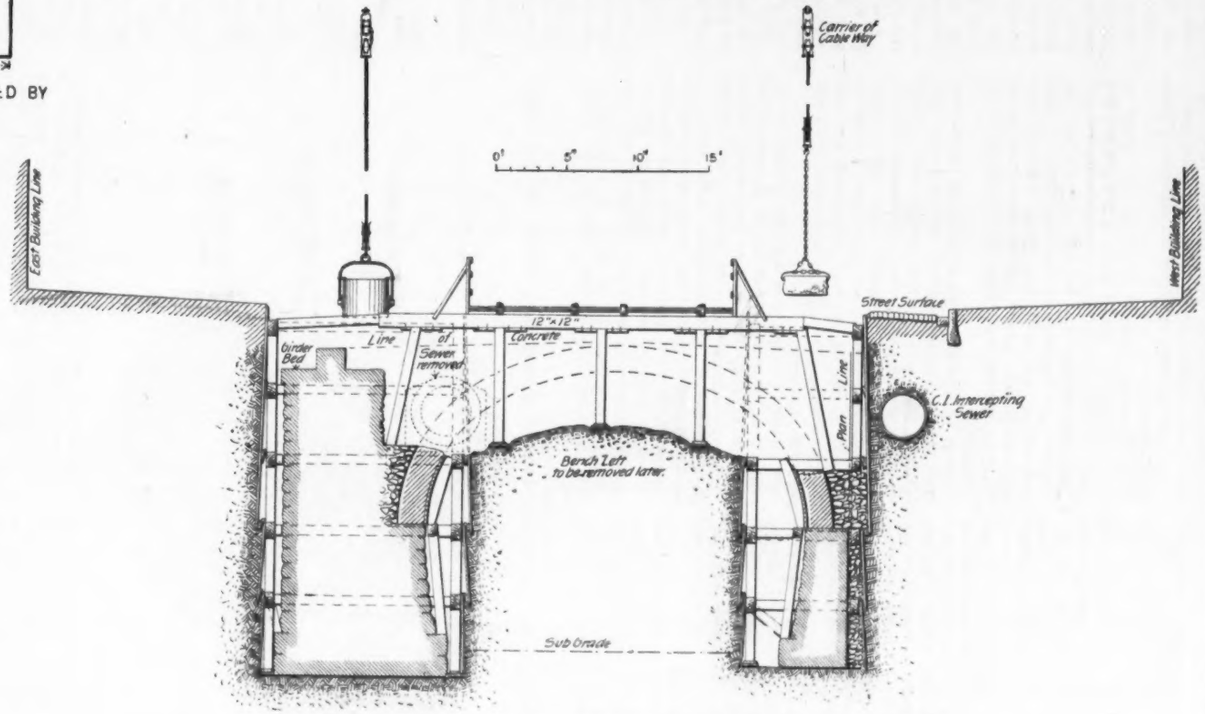


FIG. 7.—METHOD OF SUPPORTING STREET IN OPEN CUT CONSTRUCTION.

CONSTRUCTIVE DETAILS, HOWARD STREET TUNNEL; BALTIMORE BELT RAILROAD.

W. T. Manning, Chief Engineer.

Ryan & McDonald, Contractors.

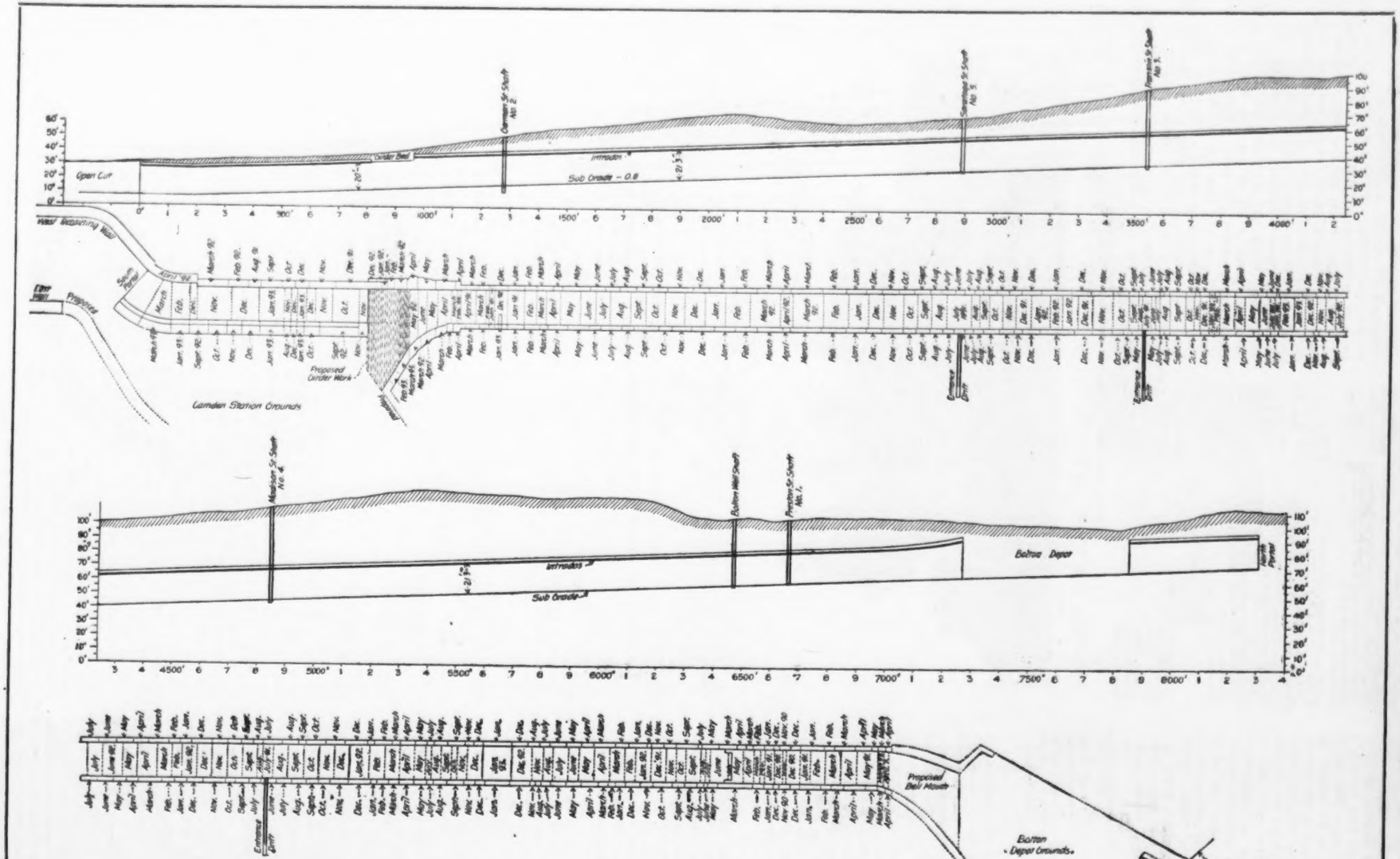


FIG. 1.—GENERAL PROGRESS, PROFILE AND PLAN.

have been taken up since 1882 under original homestead entries in the states and territories; and in 1892 these entries aggregated 7,716,062 acres. The public lands taken up under railway selections since 1882 amounted to as much as 8,343,000 acres in 1884; and in 1892 the figure was 2,765,443 acres. In the state of California alone 725,166 acres were transferred in this manner in the last year; and Nebraska figured at 531,450 acres, and Arizona at 250,751 acres, in the same period. The maximum amounts per state thus granted in the last ten years, were in 1884, when Dakota transferred over 5,000,000 acres and Louisiana over 1,000,000 acres; in 1887, when Montana gave 2,282,572 acres; and in 1888, when Washington devoted for railway extension over 4,000,000 acres of public lands. In 1892 13,566,552 acres of public lands were disposed of for cash, under the homestead acts, the timber-culture acts, located with agricultural college and other college script, and with military bounty land-warrants, or selected by states and railways. The maximum annual disposal of land, since 1882, under similar acts, script and warrants, was nearly 27,000,000 acres in 1884, and about 25,000,000 acres in 1887 and 1888 respectively.

The Commissioner of the Land Office estimates that the total available area of public lands still vacant is about 568,000,000 acres, of which 95%, as above shown, lies in the western half of the United States, mainly west of the 100th meridian, while much of the remainder is situated in the swamps of Louisiana and Florida, or in the so-called non-agricultural portions of Arkansas, Michigan, Minnesota and Wisconsin. Taking the average annual disposal of public land at 12,000,000 acres and assuming all the vacant land as susceptible to entry, the whole of it would be taken up in about 50 years. As a matter of fact, however, says Mr. F. H. Newell, of the U. S. Geological Survey, in commenting on these lands in "Science," only a small portion of this vast area can be acquired under the operation of present laws or is suitable for homestead purposes. A great part consists of high mountains, deeply eroded plateaus, steril lava covered plains or territory too rough for agricultural use. Other parts, with a deep and rich soil, but with a relatively small area, are almost valueless owing to the aridity of the climate.

Mr. Newell says that under the operation of existing laws the annual rate of the disposal of public lands must constantly diminish; and as the choice becomes more limited land will be taken up that was rejected a few years ago as worthless. The task of reclaiming this land must thus be undertaken and this brings up the question of irrigation. According to the last census an area of only 3,631,381 acres was irrigated in 1889. The area is made up of scattered districts west of the 100th meridian, and extending to the Pacific Coast. Deducting 36 counties of western Oregon and Washington, the total area of this district is 883,312,000 acres; so that only about 0.4% of this vast country is irrigated. Mr. Newall divides this total area into the following great classes, according to the amount of moisture received or water supply available, as indicated by the character of the vegetation:

	Acres.
Desert land	64,000,000
Pasture land	620,912,000
Firewood land	115,200,000
Timber land	83,200,000
Total	883,312,000

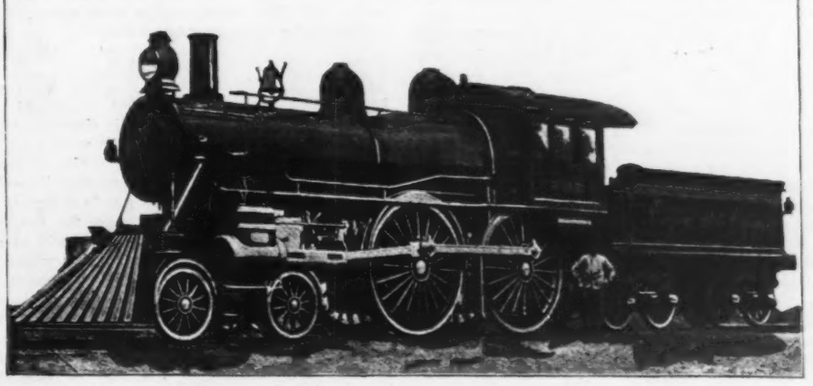
Of this land less than 568,000,000 acres still belong to the general government, and the irrigated or irrigable lands are mainly included within the areas classed above as desert or pasture lands. Of this land it is stated that fully nine-tenths of the area is covered with a rich, arable soil, which only lacks water to make it of value for agriculture, and of which less than 0.6% was irrigated in the last census year. It is evident then that irrigation is the problem to be studied and carried into effect before much of the comparatively small amount of land still at the disposal of the general government can be made useful to the citizens of the United States. To what part of this land water can be brought at all is a problem now under discussion, and until our national surveys on that head are completed the area really irrigable under any circumstances can only be very roughly guessed at.

LOCOMOTIVE FOR THE EMPIRE STATE EXPRESS; NEW YORK CENTRAL & HUDSON RIVER R. R.

The new eight-wheel engines built by the New York Central & Hudson River R. R. to haul the Empire State Express are probably the largest and most powerful engines of their type ever built, and are very handsome machines. One of these, engine No. 999, which will form part of the company's exhibit at the World's Columbian Exposition, has run a mile in 35 seconds, with the train, or at the rate of 102 miles per hour; and on a later day ran a mile in 32 seconds, or at the rate of 112 miles per hour, as noted elsewhere. We are indebted to Mr. Wm. Buchanan, Superintendent of Motive Power and Rolling Stock, for the following particulars of this very interesting locomotive.

The engine is of the standard eight-wheel or American type, with four coupled driving wheels and a four-wheel leading truck. It is a simple engine, and burns bituminous coal in a Buchanan firebox placed above the frames. It will be noted that the engine brakes are applied to the drivers and truck wheels.

Running Gear.	
Driving wheels, diam	7 ft. 2 ins.
Truck " "	3 " 4 "
Tender " "	3 " 4 "
Engine truck	Rigid center
Journals, driving axles	9 × 12½ ins.
" truck axles	6¾ × 10 "
" tender axles	4½ × 8 "
Wheel Base.—Driving	8 ft. 6 ins.
Truck	6 " 8 "
Total engine	23 " 11 "
" tender	15 " 2¼ "
" engine and tender	47 " 8½ "
Center of truck pin to center of leading driver	12 " "
Weight in working order; on drivers	84,600 lbs.
On truck wheels	40,000 "
Engine, total	124,600 "
Tender "	80,000 "
Engine and tender, loaded	204,600 "
Tender, empty	36,700 "
Of full coal capacity	13,500 "
Of full water capacity of tank	29,800 "
Cylinders	19 × 24 ins.
Distance center to center	6 ft. 5 "
Piston rod, diam.	2⅜ "
Form of crosshead and guides	Four bar guide
Connecting rod, length between centers	8 ft. 11½ ins.
Valve Gear.—Type	Link
Ports: length, 18 ins.; width steam, 1¼ ins.; width exhaust, 2¾ ins.	
Slide valves; lap, 1 in.; max. travel, 5½ ins.; lead, 1/16 in.	
Boiler.—Type	Wagon top
Diam. of barrel inside	4 ft. 9 ins.
Thickness of barrel plates	⅜ in.
Thickness of smokebox tube plate	½ "
Height from rail to center line	7 ft. 11¾ ins.
Length of smokebox	4 ft. 8 ins.
Working steam pressure	190 lbs.



LOCOMOTIVE FOR EMPIRE STATE EXPRESS; NEW YORK CENTRAL & HUDSON RIVER R. R.,
William Buchanan, Superintendent of Motive Power

Firebox.—Type	Buchanan
Length inside	9 ft. 1⅝ in.
Width inside	3 " 4⅝ "
Depth at front	6 " 1¼ "
Depth at back	4 " 10⅜ "
Thickness of side plates	⅜ in.
" back plate	⅜ "
" crown sheet	⅜ "
" tube sheet	½ "
Grate area	30.7 sq. ft.
Staybolts: hollow diam. 1 in.; pitch, 4 ins.	
Water space, width, sides and back, 3 ins; front, 4 ins.	
Tubes.—Material, charcoal iron; number	368
Diam. inside 1¾ ins.; outside	2 ins.
Length between tube plates	12 ft. 0 "
Total fire area of tube openings	4.476 sq. ft.
Heating surface.—Ratio to grate area	62.87 to 1
Tubes, exterior	1,697.45 sq. ft.
Firebox	232.92 "
Total with exterior tube area	1,930.37 "
Miscellaneous.	
Exhaust nozzle, diam	3½ ins.
Smokestack, smallest diam	15¼ "
Smokestack, height from rail to top	14 ft. 10 ins.
Capacity of tank	3,587 gallons
Capacity of coal space	13,500 lbs.
Brake fittings.—Westinghouse on tender and train. Westinghouse American on drivers and engine truck.	
Tractive force per lb. effective press. on piston. 100.74 lbs.	

THE BALTIMORE BELT R. R. TUNNEL.

(With Inset.)

In our issue of June 28, 1890, we published a map and brief description of the Baltimore Belt Ry. tunnel at Baltimore, Md., and in later issues (Dec. 12 and 19, 1891, and Jan. 16, 1892) gave very full details of the character of the work and the methods adopted in its prosecution. At that time but comparatively little had been done on the actual excavation of the tunnel, and as the work progressed it was found necessary to make some changes in the original plans, notably the introduction of an invert throughout the tunnel, and also in a few cases, owing to the prevalence of unusual quantities of water or for other reasons, to adopt particular methods of procedure. It has therefore seemed advisable to supplement our former article with a brief description of the more important of these changes.

The Baltimore Belt Ry. Co. was organized in 1890 by officers of the Baltimore & Ohio and Western Maryland railway companies and Baltimore capitalists, to build seven miles of double-track railway, mostly within the city limits of Baltimore. This railway was to be partly open cut and embankment and partly tunnel, and its object was to afford the companies named facilities for reaching the center of the city with their passengers and freight. To carry out the work the Maryland Construction Co. was organized by the parties interested, and in September, 1890, this company let the contract for construction to Ryan & McDonald.

The chief difficulties of the work centered in the construction of the Howard St. tunnel, 8,350 ft. long, running underneath the principal business section of the city, and upon this work is now approaching completion. The soil penetrated has been of almost all kinds and consistencies, but was chiefly sand of varying degrees of fineness penetrated by seams of loam, clay and gravel. Some of the clay encountered has been too hard and tough to be removed except by blasting. Rock was also found in a few places. For the most part, however, the work has been through soft ground, furnishing more or less water. In fact so much water was found in places that the only practicable method of handling the earth in the bottom side drifts was by buckets. This, of course, necessitated unusual precautions to avoid the settling of the street above and consequent damage to the buildings along the line. The method of excavation was described in detail in our former articles. It was a modification of the English bar system. Two bottom side drifts were first driven and the side walls put in, and then the top heading was excavated, the timbering being supported on a heavy fill which tested on the side walls and center core, which was removed after the roof masonry had been completed. The chief advantages of this system, which was used for the first time on this tunnel, are that the bottom drifts serve to drain the soil of the heading and core and at the same time prevent the core from spreading under the weight of the timbering, which is liable to occur if the excavations for the side walls are made after the removal of the top heading.

Turning now to the illustrations on our inset sheet it will be seen from Fig. 1 that the tunnel has been practically completed from its entrance

near the Camden Station of the Baltimore & Ohio R. R. to a point near the bell-mouth entering the Bolton Depot grounds. Work is now in progress on the entrance to the bell-mouth. From the Bolton Depot grounds two short tunnels under Mt. Royal Ave. lead to the north portal, where the open cut begins. The plan and profile plainly indicate the progress of the work and the location of the shafts and station grounds, and need no further description.

As stated before the most important change in the original plans was the introduction of a masonry invert throughout the entire length of the tunnel. It was at first intended to do without this, but as the work progressed it was found that there was danger of the side walls failing in places, and to make the work secure the engineers decided to construct an invert. Owing to the unstable character of the ground, considerable care had to be exercised in this work. Where the bottom was sufficiently stable the earth was taken out in sections varying from 2 ft. to 10 ft. in length and the full width of the tunnel. The process was as follows: Two parallel 12×12 ins. timbers were first placed transversely across the tunnel, abutting against longitudinal timbers or wedges resting against the side walls. Short sheet piles were then driven into the tunnel bottom, outside of the transverse timbers, forming an inclosure similar to a cofferdam, from which the earth could be excavated without disturbing the surrounding ground. The earth being excavated, a layer of concrete 8 ins. thick was laid and the brick masonry invert constructed. In less stable ground each of the above described cofferdams was subdivided by transverse timbers and sheet piling into three small cofferdams. Here the masonry of the middle section was first constructed and then the side sections built. Where the ground was the worst still more care was necessary, and the bottom had to be covered with a sheeting of 1¼ ins. plank held down by struts abutting against the large transverse timbers. The invert was constructed on this sheeting. The arrangement of the timbering for each case is shown in Figs. 2, 3 and 4, respectively, and a cross-section of the tunnel with the invert completed is shown in Fig. 5.

Mention has been made of the prevalence of water in most of the material penetrated. Generally this could easily be removed by suitable drains and pumps, and the earth be prevented from washing in by packing the space between the timbering and sides of the excavation with hay or other material. In a few cases, however, more difficulty was experienced. One section of about 200 ft., at City College, in particular, gave considerable trouble to the contractors. Here the pressure of water was so great as to wash in the earth despite the packing of hay and cement. The method of dealing with the water at this point is shown in Fig. 6. As will be seen, perforated pipes 6 ins. in diameter were driven into the sides of the tunnel and liquid cement forced into the earth, which solidified the ground and stopped the flow of water. The radius of penetration of the cement from the pipes was about 10 ft. In this illustration the location of the side drifts, which were constructed in advance of the top heading, and the manner of supporting the timbering of the heading on the center core are plainly shown.

An interesting feature of the work was the use of cableways in constructing about 1,200 ft. of the south end of the tunnel near the Camden Station. This section was constructed by open cut in the manner to be described. As the street carries a very heavy horse car and wagon traffic at this point, it was impossible to open up the street the entire width necessary for the tunnel. Side trenches were therefore excavated, as shown in Fig. 7, and the side walls of the tunnel put in. These being finished the street over the tunnel was replaced by the timber structure illustrated as fast as the material was excavated. This timber platform, of course, covered only the section upon which work was in progress; the tunnel being arched over and the street filled in and repaved, as closely as possible following the platform. The general design of the support is so clearly shown in the illustration as to need no further description. It was in excavating the side trenches that the cableways were used, one being placed on each side directly over the trenches. These were used in conveying both the excavated material and the stone, bricks, etc., for the masonry, it being found that the stone could be set by the cableway without the use of the usual derrick. Both cableways were of the well known Lidgerwood Mfg. Co.'s type, with main cables 2 ins. in diameter and hoisting and traversing ropes ⅝ in. in diameter. The advantages to be gained by the use of cableways in this case are obvious when it is considered that no hindrance is opposed to the street traffic, which can be carried on directly underneath the apparatus. The dimensions of the tunnel section constructed by open cut are shown in Fig. 8.

The entire work, owing to the unstable character of the ground penetrated, has been of such a character as to demand constant attention on the part of the contractors and engineers to prevent accidents. Some damage to the adjacent property was, of course, unavoidable, but considering the size of the tunnel and the value of the property along the route the damages have been remarkably small in amount. As before stated the work was in direct charge of the Maryland Construction Co., with Ryan & McDonald as contractors. The engineers of the construction company were: W. T. Manning, Chief Engineer; John B. Bott, M. Am. Soc. C. E., Assistant Engineer; W. Howat, Resident Engineer, and John Riley and Janon Fisher, Division Engineers. The engineer for the contractors was H. B. Reed, who had for assistants D. W. Henning and H. C. Sanford. The general management of the work was in charge of Mr. E. J. Farrel, who was associated with Ryan & McDonald in the contract. We are indebted to the contractors and engineers for the matter from which our illustrations and this description have been prepared.

AMMONIA GAS AS A SOURCE OF MOTIVE POWER.

By T. Waln-Morgan Draper, C. E.; M. E.

Ammonia, NH_3, at the temperature of our atmosphere is a permanent gas of a well known pungent odor. It is formed by the union of three volumes of hydrogen and one of nitrogen, condensed into two volumes. Its density is 0.596, air being 1.00. It is about one-fourth lighter than that liquid. The volume of ammonia gas is 983 times greater than the space occupied by its liquor, while steam, under identical pressure, occupies a space only 303 times greater than water. Comparing water and ammonia we find:

	Water.	Ammonia.
Ratio	1.00	.76
Boiling point	212° F.	−38.5° F.
Relative volume	1.728	1,313.28
Latent heat	990	752

Ammonia is a powerful alkali, rivaling potash and soda, and it can neutralize the most powerful acids. Its action on most metals is nil; on copper it acts slightly; while not touching iron, it readily dissolves iron rust. Ammonia gas is absorbed by water with avidity, depending upon the temperature of the latter; at 80° F., one part will absorb about 700 parts of gas. The absorbing water becomes specifically lighter while its volume is being augumented one-third. As the absorption continues the water becomes heated and the latent heat of the gas reappers as sensible heat. It is in this property that water possesses, of absorbing such volumes of gas and of becoming heated while doing so, that the key is found to the use of ammonia gas as a practical motive power. For one must always bear in mind that the only agency for producing gas is heat. The initial temperature of steam at 150 lbs. pressure is 446° F.; that of ammonia is 80° F. A thoroughly saturated solution of ammonia at 60° F. contains 30% of ammonia.

I have ascertained the relative pressures exerted at various temperatures of the gas, from practice, to be:

Temp., deg. F...	50	60	70	75	80	85	90
Pressure lbs. per sq. in.....	92.5	110	129.5	138.75	147	157.25	166.5

The knowledge that anhydrous ammonia gas could be used as a power to drive an engine is not new, by any means; but within the last few years, because of the multiplying of inventions and many mechanical improvements, this very useful and important power has been made practicable, as easily handled as steam, which it in many ways resembles, and which it is designed in many instances to to supplement and supplant.

Gamjee patented an ammonia engine, so did Seyforth, Jean Frot, Lanback, Dr. Emile Lamm, P. J. McMahon, and these have been followed and copied by many others. The inventions of Dr. Lamm and Mr. McMahon are closely identical; they follow the same principles and use similiar apparatus.

I do not hesitate to make the very broad statement that anhydrous ammonia gas will do anything as a power that steam can do, and more, and do it at less cost. The only serious questions being:

1. Cost of production and operation.
2. Fittings, and, coincident with the latter, smell.

Under the question of cost of operation the latest inventions conclusively prove that it is very small. The ammonia of commerce, consisting of about 30% ammonia and 70% water, is sold at 5½ cts. per pound, there being about 8 lbs. to the gallon; and, as this is not lost (excepting about 10% per annum) but is used over and over, this should be estimated in the first cost of the plant, and not in the operating. As the basis of cost of operation by actual running, I will take the tests made on a McMahon motor car at Chicago, stating, however, that the price of the coal used was $5.75 per ton—much higher than would be the cost ordinarily. The motor was on an ordinary street car; the track used was a new and very rough one. The amount of coal and cost of ammonia are figured from two test runs, made Dec. 11, 1891, and Feb. 15, 1892. The majority of the runs were made in cold weather, and in all the pressure on the gage was greater after making the run than at the start:

Tests of Fuel Consumption of an Ammonia Car.

Date, 1891.	Temp. degs. F.	Press. atmos.. gas.	Miles of run.	Gals. anhyd. used.	Lbs. of coal.	No. gal. pr. mile.	Cost per mile. cts.
Dec. 8..	35	140	5	26	36.00	5.2	1.48
12..	40	190	8	35	42.00	4.37	1.25
15..	30	160	9	43	51.6	4.77	1.31
19..	20	190	10	46	55.2	4.6	1.30
29..	10	160	12	57	68.4	4.75	1.35
1892.							
Feb. 9..	4	180	8	36	43.2	4.5	1.28
March 13..	25	160	14	53	63.6	3.78	1.07
16..	10	160	18	57	47.2	3.19	0.937
19..	33	110	17	54	44.5	3.18	0.797
22..	36	160	6	20	16.50	3.33	0.833
27..	30	170	8	24	21.00	3.00	0.75
15..	25	180	10	31	27.8	3.1	0.775
21..	28	160	12	35	28.8	2.91	0.727
26..	37	180	14	40	35.00	2.85	0.712
April 9..	20	170	8	27	22.14	3.37	0.83
16..	50	180	6	21	17.22	3.5	0.875
21..	42	175	8	28	22.96	3.5	0.875

It is very difficult to obtain accurate figures as to cost per mile of operating various systems now in use. A careful comparison of the electric trolley, cable and horse car systems, which is approximately correct, shows:

Horsecar	21.25 cts. per mile.
Cable	14.12 " "
Electric trolley	13.25 " "
Ammonia gas	7.68 " "

The installation of the ammonia gas system can be accomplished for a very moderate sum in comparison with the others, and no changes are necessary in tracks or streets now in use by other methods. Taking, for instance, the Third Ave. cable line now in course of construction, and which, it is currently reported, will cost $6,000,000, or, if they operate 200 cars, $30,000 per car. This entire plant could, with the ammonia motor system, be put in, minus the annoyance to thousands of people caused by the construction of the cable road, for an average of $3,000 per car, or $600,000 in all, which would include the power plant, cars, motors, etc.

The new motor has only been tried in connection with street car service as yet, but there is no reason why it should not be used for any other service that steam now performs. Gamjee's ammonia engine was a stationary one, so that it would seem that its adaptability is fully proved.

The question of fittings, a most important one in the use of ammonia, has recently been solved in a most satisfactory manner. Ammonia fittings must be absolutely tight up to a gas pressure of 200 lbs., otherwise gas is lost internally and externally, without results, and makes a pungent smell and a nuisance. No ammonia motor could be placed in any service unless it was free from odor or other nuisances.

Fittings especially designed for high pressure have been in use for some years, especially since refrigerating plants have become numerous. These, however, have been of great weight and size, and difficult to handle or adjust in close quarters. Not long since a new joint was invented which is now being largely used for high pressure. This joint

is similar to an ordinary screw coupling, of malleable iron, except that a groove is cast in the threaded portion of the fitting, into which a collar or ring of lead is run. This is formed upon a threaded mandrel of slightly smaller size than the coupling, so that the lead projects a very little beyond the threads. A small hole with a thread cut upon it is made through the exterior of the coupling into the lead-filled recess, and a small set screw inserted. If now a pipe is screwed into the coupling it will expand the leaden packing, causing it to tightly fill the screw threads, and if the joint is not made tight by this means, one or more turns of the compressing screw crowds the lead around the pipe and makes it absolutely tight. I have thoroughly tested these joints in the shape of tees, ells and couplings, and I am satisfied that no leakage can occur which cannot be instantly stopped by one or two turns of the set screw. In addition to this, the dimensions of the couplings are not greater than those of ordinary extra heavy fittings. In weight there is an enormous difference; for instance, the old style of 1-in. ammonia elbow weighed 13½ lbs., the new 1½ lbs.; the old 1¼-in. elbow weighed 18½ lbs., the new 2 lbs.; the old 2-in. weighed 29 lbs., the new 4 lbs. The old style 1-in. tee weighed 15 lbs., the new 3½ lbs., and so it in through all the different sizes. This is a matter of great importance in ammonia engine construction, as absolutely tight joints save power and create no undesirable nuisance. The saving of weight and space is also important.

A brief description of the methods employed in producing the anhydrous ammonia, and its use as a motive power, is as follows:

The commercial ammonia is introduced into a solution still, which resembles in many ways an ordinary tubular boiler. It has a firebox under one end, from which the heat passes under the boiler, thence back through tubes and out at the stack. The ammonia solution is introduced into the boiler, which is slightly elevated at the end farthest from the firebox, and falling first on the scattering plate it passes along the end of the boiler slowly, being robbed by the heat of its gas. The point of temperature at which ammonia leaves water at great rapidity as a gas is 90° F below the boiling point of water, or 122° F., although it will evaporate slowly in any ordinary temperature. In order that a proper distribution of the solution shall take place in the still, vertical plates of thin sheet iron are set 2 ft. apart alternately 2 ins. above the bottom of the shell, and close to it, thus forcing the solution to take a varied course toward the blow-off end. By the time it has reached this point it has lost most of its ammonia, containing only from 5% to 7%; yet, as explained further on, this residue is not undesirable. The ammonia gas rises through the scattering plate to an upper cylinder called a dehydrator.

This is a round cylinder, on the bottom of which is a scattering plate; above this is a number of tubes, through which cold water passes. The gas rising from the still flows through the scattering plate and over and around the cold water tubes, and is completely dehydrated, or losing its watery vapor thereby becomes a perfectly dry gas. From here it passes to a set of coils, over which cold water is constantly falling, and in these coils it condenses to a liquid anhydrous ammonia, which is collected in a tank.

The motor, whether placed under an ordinary street car or used as a locomotive or stationary engine, receives two charges; one of anhydrous ammonia, the other the deammonianized fluid from the solution still. The liquid anhydrous ammonia is charged into an inner tank or tanks, and the blow-off solution into the outer tank, which completely surrounds not alone the inner tank, but also the evaporating tubes (answering to the heating surface of the steam boiler), which are located below the inner tank, and connected with it by pipes at either end, the ends of the evaporating tubes being fastened in manifold. About 5 sq. ft. of evaporating surface is reckoned as 1 HP. The deammonianized solution in the outer tank is charged from the still into the motor at a temperature of 80° F., which temperature causes the anhydrous ammonia in the evaporating tubes to vaporize rapidly with a pressure of 147 lbs. per sq. in. The temperature of the absorbing fluid into which the gas is discharged from the engine, as hereinafter described, is maintained by the constant evaporation of the gas, robbing the tubes of their latent heat. The latent heat of the gas is given out in the absorbing liquid, and this heat is being continually transmitted through the metallic surfaces of the inner reservoir to keep up the evaporation as long as any of the anhydrous liquid remains in the reservoir. The gas from the tubes rises up through the anhydrous liquid to a special gas chamber, or the upper part of the anhydrous tank, or tanks, may be used for this purpose, from whence it is supplied as is steam to the cylinders, under a pressure of 147 lbs., this pressure varying, of course, with the rise and fall of the temperature. The exhaust from the cylinders is carried into the solution in the outer tank, where it is instantly absorbed. There is consequently no discharge or exhaust into the outer atmosphere and no smell, as the absorption is rapid and complete.

When the stored power of a charge is expended, the contents of the outer tank will have become a concentrated solution of aqua-ammonia This is withdrawn at the central station, to be reseparated, and new charges are introduced.

The actual cost is, in comparison with other motive powers, very small. Great care in construction, and the use of only the best material and careful supervision, will prevent any untoward results; but with all this carefully looked after, which experience and practice will make perfect, there seems to be no reason why these motors for railways, mines, stationary engines or car service may not be used, as a great saving in first cost, weight and operation, is assured.

A DEVICE FOR COLLECTING WATER FROM LAKES OR STREAMS FOR ANALYSIS.

The value of water analyses depends very largely upon the methods employed in collecting samples. A simple and, it would appear, thoroughly satisfactory device for collecting water from any required depth is shown by the accompanying cut, which is taken from the London "Lancet" and was used in collecting samples for its investigation of the Chicago water supply, noted in our issues of April 6 and 20 and May 11.

Apparatus for Collecting Water for Analysis.

The "Lancet's" directions to its agent for the use of the collecting device were as follows:

A sinker accompanies the bottles, which may be used in the following manner: The bottle is introduced into the tin holder and made fast therein by means of the wire strap which passes over its shoulder. The glass stopper is then to be with drawn and the cork stopper sugstituted in its place. The weight must next be attached to the bottom of the tin holder, and the whole sunk to the redepth, as indicated by the metal tabs upon the suspending cord. This done, a pull upon the stopper cord will draw the cork and the bottle will fill. The bottle is then to be drawn gently up to the surface, and the glass stopper introduced while the neck is still immersed. The bottle may then me taken out of the water and the stopper tightened in its place, after which it should be immediately tied with string. When home or a convenient stopping place is reached, the parchment caps must be placed over the stoppers, the stoppers tied on and the string sealed. The caps are to be made lissom by soaking them in water for a few minutes before use.

The first Spanish railway line was opened to traffic in 1845. Since that year 6,201 miles have been built, representing a total capital, in stock and bonded debt, of $901,226,250.

RECENT EXAMPLES OF ELECTRIC POWER DISTRIBUTION.

At the meeting of the New England Cotton Manufacturers' Association on April 26 a paper was read by C. J. H. Woodbury, M. Am. Soc. C. E., describing recent developments in electric power transmission and distribution. He stated that multiphase synchronous motors will be used in transmitting power from Sewall's Falls on the Merrimac River to Concord, N. H., a distance of about four miles. There is a total available power at this place of about 5,000 HP. and it is expected that about 3,500 HP. will be transmitted and utilized the coming summer.

At the new works of the Page Belting Co., at Concord, power is distributed electrically from dynamos in the old works. The whole cost of the electric apparatus was 20% less than would have been required for a steam plant applied in the usual manner. The saving in power is also great. The largest size shafting in use in the new works is 2½ ins.; but if the transmission had been solely by shafting and belts the main shaft would have been at least 5 ins. in diameter. An incidental advantage of this method of power transmission is that there is not a single open hole in the floors of the new buildings. The openings for the steam pipes are packed around with asbestos.

At a new South Carolina cotton mill an electric motor drives the line shafting in each room. At the Crocker-Wheeler electric works, at Ampere, N. J., the heavier machine tools are driven by an attached motor, and in place of using cone pulleys to regulate the speed the motor itself is made to run at the speed desired. For the lighter tools one motor drives a line shaft from which power is taken in the usual way.

One of the most valuable applications of the electric motor is to the direct driving of calico-printing machines. At the Dunnell Print Works at Pawtucket a motor has been at work for 18 months driving a seven-roll printing machine. The uniformity of motion and the ease and smoothness with which the speed can be regulated have enabled the cloth to be printed at 50% greater speed than by the old steam driven machine; and allowing for stoppages to change rolls at least one-third greater output per machine is obtained. This gain on a machine whose first cost is about $50,000 is an important one. The success of the application has been such that it is believed that in building a new print works it would be advisable to equip the whole establishment for electric power transmission.

A NEW HOISTING AND TRANSFERRING APPARATUS.

It is not often that we have the privilege of illustrating and describing a piece of machinery which promises to be of such practical value to a multitude of our readers as that which is shown in the accompanying engravings. Briefly described, it is an apparatus for hoisting and transferring which will do anything and everything which can be done by an overhead traveling bridge crane, but which costs but a trifle compared with that expensive machine, and which can be operated with much less power and lighter running expenses in every way.

The principal constructive features of the apparatus will be readily understood by comparing them separately with the corresponding features of the ordinary travelling crane.

In the apparatus shown in our engravings the overhead bridge of the traveling crane is replaced by a wire rope or ropes—practically a substitution of a suspension bridge of the simplest form for a truss or girder bridge. This suspension bridge is supported on carriages which run on transverse tracks at each end of the span, just as do the carriages of the girder crane; but the carriages of the suspension bridge and the structure on which they run are of course designed to take up the horizontal strain due to the pull of the suspension cable, as well as the vertical load.

Again, in the bridge crane the machinery which hoists the load and propels the trolley back and forth across the bridge, and the bridge back and forth along its tracks, is mounted on the bridge itself, and is either driven by an independent motor mounted upon the bridge, or by a square line shaft

with a complicated arrangement of bearings, or by a wire rope kept constantly running at high speed. In the apparatus shown in our engravings, the three motions of the weight to be hoisted, of the trolley on the suspension bridge, and of this bridge on its tracks, are all effected by a simple stationary machine, which can be placed in any convenient position, and may be operated either from the line shaft of a factory or by an independent motor, as desired. In either case, but especially in the former, only the power which is actually required to operate the apparatus is used, and no power whatever is wasted when the hoist is not in use.

We can give our readers a good idea of the value and capabilities of the machine by describing briefly the circumstances under which it was developed. The Wilson & Baillie Mfg. Co., of Brooklyn, N. Y., have for some years been extensively engaged in the manufacture of concrete sewer pipe by hand labor. About two years ago, an ingenious machine for making concrete pipe, invented by Mr. Willis D. Sherman, formerly of Omaha, Neb., was put in operation in their factory. It proved such a success, and its output was so large, that the storage yard where the pipe is piled until it is needed for use was no longer large enough to accommodate the stock which the firm desired to keep on hand. Up to this time, all pipe in the storage yards had been handled solely by human muscle, being drawn on the trucks from the drying kiln to the yards, and lifted by workmen from the trucks to the storage piles. Under this arrangement it was necessary to leave an open road between every two piles of pipe, and the pipe could not be economically piled to a greater height than about 6 ft. from the ground, or the height to which a man standing on a truck could lift a heavy pipe.

It thus became necessary to make a heavy investment in additional land for a new storage yard, unless some form of hoisting and conveying apparatus could be installed which would enable the pipe to be economically piled to a greater height. The yard is over 200 ft. long and 100 ft. in width; and several of the principal manufacturers of hoisting and conveying machinery were applied to for a plant suited to the needs of the company. As none of them could furnish machinery which fulfilled the necessary conditions, Mr. Willis D. Sherman, whose ingenious pipe-making machine got the company into the quandary, undertook to devise an apparatus which should get it out.

We have outlined above the most important general features of the "Sherman Aerial Hoisting, Carrying and Distributing Apparatus," and our illustrations show it in operation, and are made from recent photographs taken expressly for this journal. Fig. 1 is a general view of the storage yard, with the mill and derrick hoist beside the Gowanus Canal in the background. The area controlled by the hoist is a rectangle 215 × 100 ft. The entire length of the rope span is 215 ft. The hoist is designed for a maximum load of one ton, but its design to carry a greater load involves merely a heavier main cable and sufficient strength in the trestles at the ends to withstand its pull. The trestles at the Wilson & Baillie yards are 30 ft. high. Each bent consists of a vertical member braced by a strut inclined at an angle of about 30°, and both footing on a ground sill. These three members are each 10 × 10-in. yellow pine. A pile is driven under the sill at each end, and the vertical member of each bent is anchored to the pile beneath it to prevent the trestle tipping under the pull of the cable. The horizontal timber carrying the tracks on which the carriages run is 12 × 12 ins., as it has to take a heavy transverse strain between the bents. The main cable on which the trolley runs is a one-inch wire rope, secured at each end to a carriage. Its deflection at the center under a load of one ton is 4 ft. It should be especially noticed that this main cable does not pass around any sheaves, and hence can be made of any size desired. The running cables, by which the various motions of the carriages, trolley and hoist-hook are controlled, are 5-16 in. in diameter. The winding drums operating these ropes are combined in one machine, which is placed in this case at one end of one trestle. This position is chosen because the operator has a clear view of the whole yard, and can respond more readily to signals from any part of it, and can thus place the pipe or other material at any desired point in the yard. If necessary, however, to locate the machine elsewhere, it is merely a matter of leading the ropes to it over suitable sheaves. It is to be especially noted that in its position on the end of the trestle the machine does not interfere with the use of the extreme end of the trestle. The carriage on that trestle can run clear into the operating house, and is thus shown in our perspective view of the winding drums, Fig. 3.

The advantages of operating the machine by a shaft driven by the main engine are very great. Small independent engines, such as are generally used on steam cranes, are wasteful of fuel, and require frequent attention. Repairs to either the square shaft or flying rope system of driving overhead cranes are a heavy item. The electric cranes, except in shops which already have power circuits in operation, require a constant service from a dynamo, even though the crane may be in use but a small portion of the time. With the Sherman apparatus, however, power from a line shaft may be used in every case where it is available, and, where it is not, a steam or electric motor can be used as readily as with any other system.

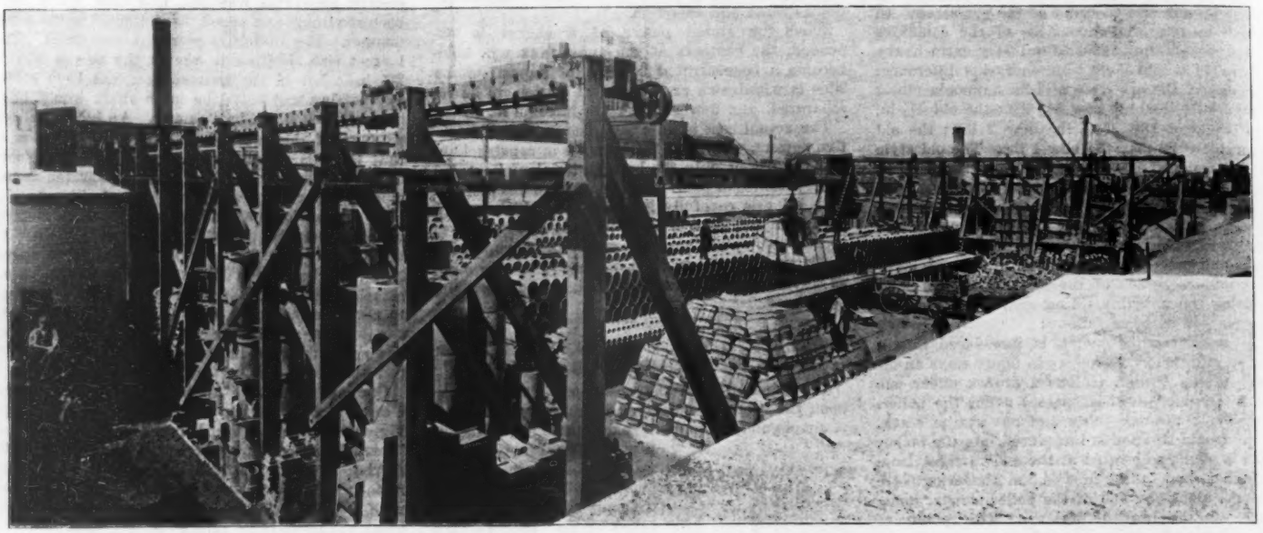


FIG. 1. THE SHERMAN HOISTING AND TRANSFERRING APPARATUS IN THE YARDS OF THE WILSON & BAILLIE MFG. CO.; MAKERS OF CONCRETE SEWER PIPE.

Fig. 3. Winding Machine and Traveling Carriage in Operating Cabin.

The details of construction of the trolley, carriage and winding drums will be understood by examination of Figs. 2 and 3. The ropes which pull the trolley back and forth along the main cable and the carriages along the trestles are endless ropes, running once around grooved pulleys in the operating house, and are thrown in and out of gear with the main shaft by levers. The hoisting rope, on the contrary, is wound on a drum in this house, and is hauled in or paid out as desired. A friction clutch sets the winding drum in motion, and the descent is controlled by a band brake, operated by a treadle.

The trolley is shown well in Fig. 2. It will be seen that the frame in which the fall block runs is very heavy. This is necessary in order that the empty block may outweigh the slack rope on the hoist line. Otherwise the block would not run down when the hoist rope was slacked, but, instead, the hoist rope on either side of the block would sag down. It may be objected to that this is adding dead weight to be lifted and transferred; and, of course, a certain amount of power is wasted in this way. Its amount is trifling, however, compared with the saving due to other causes. Of course, if the size of the hoist rope is increased in order to lift heavier loads, or if its length is increased with increase in the span, then the fall block weight must be increased, and for spans above 300 ft. probably the use of fall-rope carriers would be advisable. With such carriers the span could be increased to any desired length.

The use of a suspension cable for carrying the load in place of a truss or girder, results in some

very important advantages. In the first place, it has always been a troublesome question with the ordinary bridge crane how to make both ends of the bridge travel at the same speed and keep square with the tracks, for, if from lost motion or elasticity in the driving machinery, one end of the bridge travels faster than the other, the connections of the bridge to its trucks may be strained, or the bridge may be derailed. But when a suspended cable takes the place of the girder or truss, this difficulty disappears. If the carriage on one trestle is a few inches ahead of that on the other trestle, it makes no difference of practical importance. Indeed, with long spans there might be several feet difference in the position of the two carriages without any appreciable increase in strain. We allude to this matter only because it has been so much talked about in connection with the propulsion of bridge cranes, and it might be a question in the minds of some with respect to this apparatus. Should such a question arise in the mind of any reader, the answer is merely that the carriages on the two trestles do, as a matter of fact, travel in perfect unison, so far as the eye can discern; and even if they did not it would not interfere one particle with the safety or smooth-working of the apparatus.

Another advantage of this apparatus over the bridge crane is that, whereas with the bridge crane most of the transferring is done by the bridge· with this system most of it is done with the trolley. For example, the yard shown in our illustrations is 215 x 100 ft. With the cable system the trestles are placed across the ends, and the cable spans the length of the yard. But if a bridge crane were to be installed to cover this area, the trestle supports would necessarily run along the sides of the yard, and the bridge would span its width. Its span would even then be extremely long for a bridge crane. In operating either, much more transferring is done along the yard or shop than across it. For example, in the yard shown in Fig. 1, a truck taking a load of pipe from one pile will draw up at the end; the cable will be placed over it, and the trolley will then run back and forth along the cable, picking up the pipe and conveying it to the truck. In a heavy machine shop the machines are generally ranged along each side, leaving an open passageway between. In carrying the work to and from the machines the bridge crane will often run the length of the shop. The advantage of having the trolley do the bulk of the work instead of the bridge arises from the fact that the trolley is a much lighter and simpler machine. It can be renewed at small cost compared with the span and carriages which support it, and it can be stopped and started more quickly, and run at a much higher rate of speed than can the bridge.

Another advantage in having the span cover the length instead of the width of the space controlled is that less trestling is required. In the present case 200 lin. ft. of trestle is used for the cable system, while if the span ran the other way 430 ft. would be required. This will probably about balance the extra cost of the trestling for the cable system, due to the fact that it has to sustain both a vertical and a transverse strain.

We have alluded to the simplicity of the machine which controls the hoist, trolley and carriages. An advantage which appeals with great force to the practical man is that hoisting and transferring is done on a bee line. If a load is to be picked up at one corner of the yard and transferred to the corner diagonally opposite, both the trolley and the suspended span are moved together, and the load goes straight to the desired point.

We have thus far described the machine in comparison with traveling bridge cranes; but, aside from the fact that it is adapted to spans which the bridge crane cannot approach, and is applicable to hundreds of uses where a bridge crane is out of the question on account of its cost, the Sherman apparatus may be varied to suit widely different situations. Instead of controlling a rectangle, a circle or any arc of it might be controlled, the trestle being built on the circumference, and the cable span extending to a fixed tower at the center, where the operating mechanism would be located. We understand the designs are already under way for a plant of this sort.

In contractors' work, too, the apparatus should have wide applications. The cable-way hoist has already proved its advantages on many large works, and this apparatus is a cable hoist which needs no assistance from portable derricks, but places material at any desired point without the intervention of hand labor. Moreover, the whole plant is simple, light and inexpensive, and is easily and quickly set up and taken down.

Probably the most important uses of the system, however, will be found in its application to situations for which no suitable machinery has heretofore existed. The stock yards of bridge-builders, rolling mills, furnaces, lumber dealers, and the

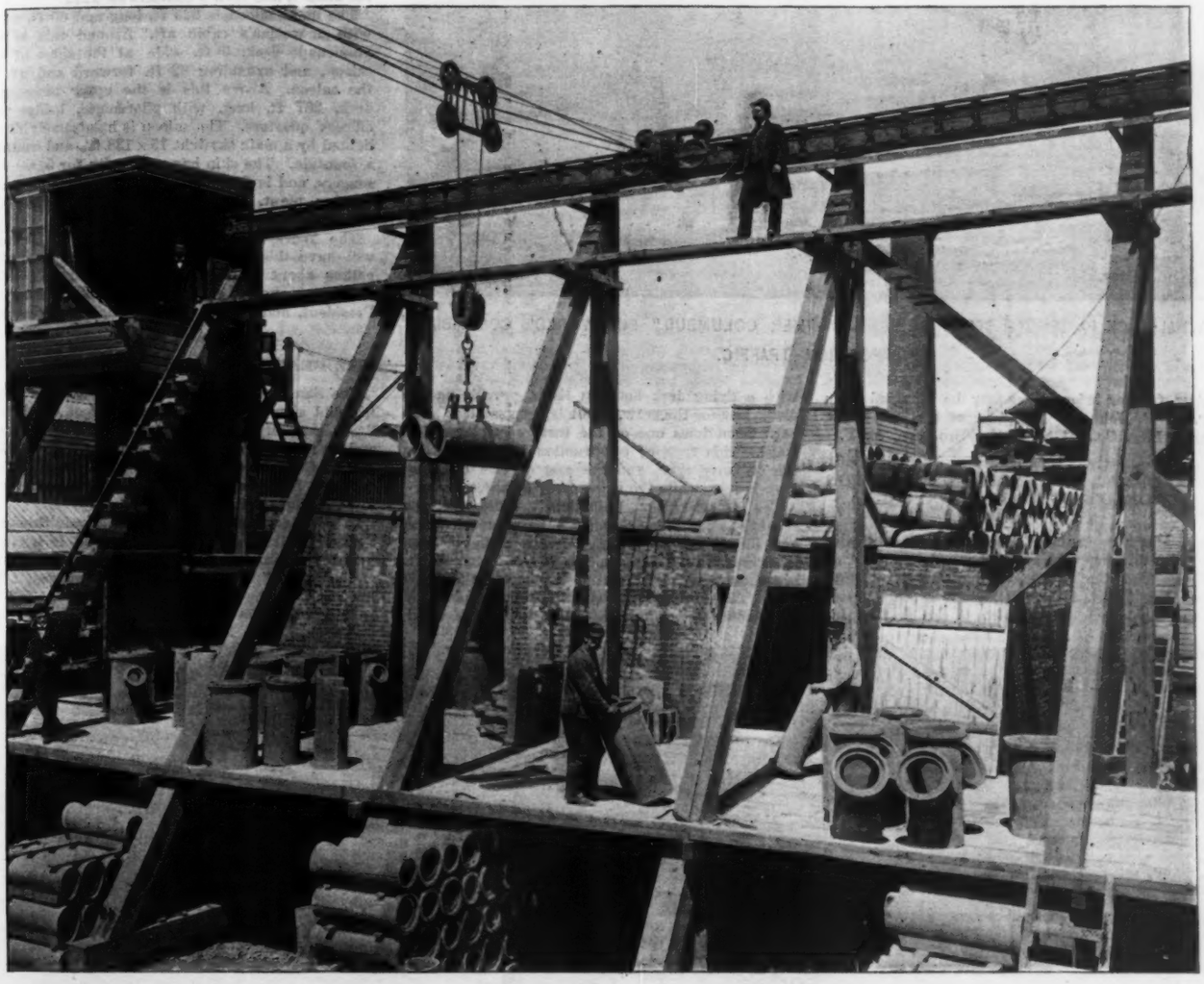
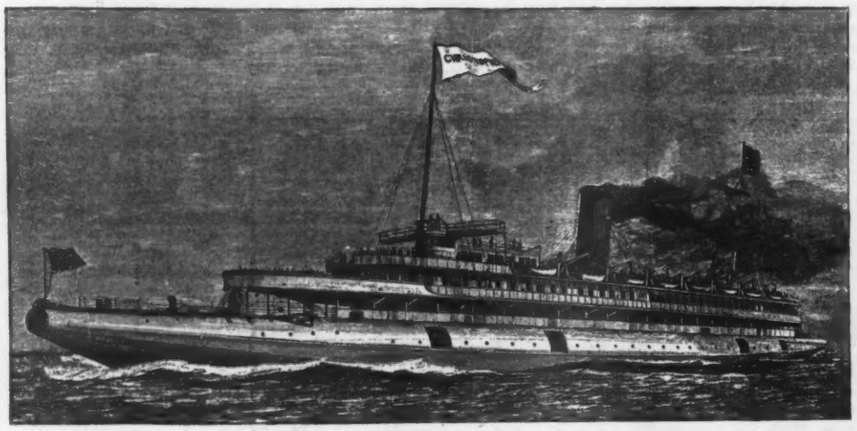


FIG 2. THE TROLLEY, TRAVELING CARRIAGE AND OPERATING CABIN, SHERMAN HOIST AND TRANSFER APPARATUS.

makers of and dealers in a thousand and one bulky or heavy articles, will have their capacity greatly increased by the use of this system, and at a moderate cost. In fact, the applications of the system are so numerous that it is difficult to say just where its limits will be found.

Patents have been secured on the apparatus in the United States and foreign countries, the American patent being No. 494,389, issued March 28, 1893. Our readers who wish to study further the details of the mechanism will find it fully illustrated and described in the patent.



WHALEBACK PASSENGER STEAMER, "CHRISTOPHER COLUMBUS" FOR WORLD'S COLUMBIAN EXPOSITION TRAFFIC.

Any further information may be obtained from Mr. C. B. Johnson, President of the Wilson & Baillie Mfg. Co., 93 Ninth St., Brooklyn, N. Y.

WHALEBACK PASSENGER STEAMER FOR WORLD'S COLUMBIAN EXPOSITION TRAFFIC.

The steamers used by the World's Fair Steamship Co. to carry passengers between the city of Chicago and the World's Columbian Exposition (Eng. News, Oct. 13, 1892) include a large vessel of the whaleback type, which is the first of its kind adapted for passenger traffic. The hull is of steel and was built by the American Steel Barge Co., at West Superior, Wis., to the designs of Capt. A. McDougall, inventor of the whaleback type of construction. The iron was manufactured from Minnesota ore by the West Superior Steel & Iron Co. (Eng. News, Jan. 19). The ship was launched Dec. 3, 1892.

A number of these ships have been built for freight traffic, mainly for grain, and the accompanying cut, represents a view of the shipbuilding yards, with several whalebacks on the stocks. The hull is of approximately oval or elliptical section with a bow ending in a blunt point or "snout," which being fitted with hawseholes, bearing a resemblance to eyes, has given these craft the nickname of "pigs." The engine is carried at the extreme stern, and one or two turrets at the stern, with a flying deck between them, provide accommodations for the crew, which is very small in number. Sometimes one of the turrets is placed forward. This type of construction is cheaper than the ordinary type, and the cost of fuel and running is less, while the ships carry a larger cargo.

The "Christopher Columbus," built for the World's Fair Steamship Co.'s passenger service, and illustrated above by a cut reproduced from the "Scientific American," is 362 ft. long, 42 ft. beam and 24 ft. deep, with a displacement of 4,000 tons. The hull is divided into compartments by nine transverse watertight bulkheads and a longitudinal bulkhead; there is a double bottom with compartments for water ballast. There is a screw propeller 14 ft. diameter and 19 ft. pitch, driven by a triple expansion engine with cylinders 20, 42 and 70 ins. diameter. Steam is supplied by six Scotch boilers 11 ft. diameter and 12 ft. long, carrying a steam pressure of 160 lbs. per sq. in. The engines were built by S. F. Hodge & Co., of Detroit, Mich. The ship is expected to have a maximum speed of 20 knots and to make the run of seven miles between the city and the Exposition pier in half an hour.

The superstructure, consisting of the promenade decks with saloons and pilot-house and officers' quarters, is supported by seven steel turrets of elliptical form. The first is 19×13 ft. and contains the windlasses; the second and third are 18×26 ft. and contain stairways; the fourth is 27×18 ft. and contains the smokestack, ventilators and ash-hoist; the fifth is the same size and incloses the top of the engine-room; the sixth and seventh contain stairways. The main deck is in the hull, with four wide gangways on each side, dining and refreshment-rooms amidships, and the kitchen and crew's quarters forward

The main saloon is 225 ft. long and 60 ft. wide, with a women's cabin aft. Around this is the promenade deck, 5 ft. wide at the sides of the saloon, and extending 32 ft. forward and aft of the saloon. Above this is the upper promenade deck, 257 ft. long, with pilot-house, bridge and officers' quarters. The saloon is handsomely fitted, lighted by a main skylight 15×138 ft., and contains a fountain. The ship has a capacity for 5,000 passengers, and is fitted with electric light and steam heating plant. The cost complete is given as $350,000.

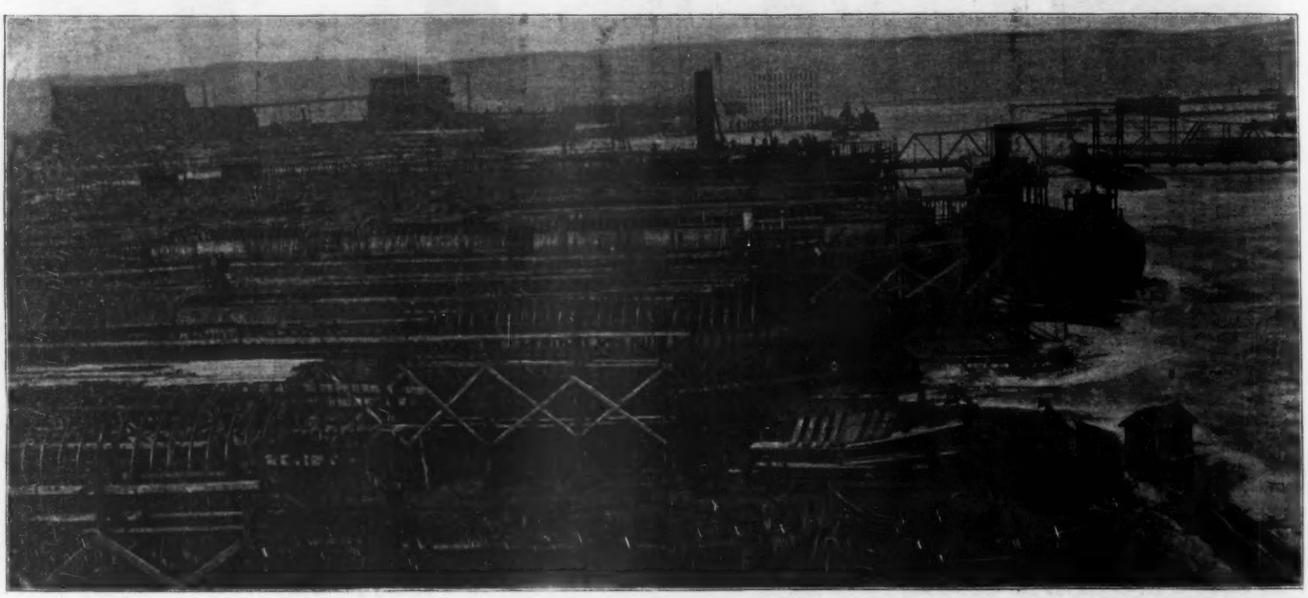
The World's Fair Steamship Co., of Chicago, will have this one whaleback steamer, and altogether about 30 vessels carrying from 1,000 to 5,000 passengers each. Mr. J. H. Bradley is President, and Mr. A. McDougall, Vice-President.

THE BEARING VALUE OF PILES IN MUD.

The San Francisco Harbor Commission is about to build a new ferry-house at the foot of Market St. in that city. The foundation material is mud, and as the structure is to be supported upon piles, Mr. H. C. Holmes, the Chief Engineer of the Commission, has been making some experiments to test the character of the material.

In February last, says the "Mining and Scientific Press," he drove a pile 92 ft. long and 16 ins. and 8 ins. in diameter, at the two ends, on the site of the ferry-slip. The hammer used weighed 2,900 lbs., and at the last blow, with a 20-ft. fall of hammer, the pile sank 3 ins. The pile was then 73 ft. in the mud. A platform, 12×4½ ft. was then built around the pile and was loaded with 90,000 lbs. of pig-iron; but after an interval of 24 hours under this load no sinking of the pile was perceptible.

The plans call for piles 18 ins. in diameter at



WHALEBACK STEAMERS UNDER CONSTRUCTION AT THE YARDS OF THE AMERICAN STEEL BARGE CO.; WEST SUPERIOR, WIS.

the butt driven 80 ft. into the mud, or 106 ft. below city datum. They are to be cut off 26 ft. below datum and on them will rest the concrete piers forming the depot foundation. Mr. Holmes concluded from his experiment that the pile foundations would successfully answer the purpose intended.

PERSONALS.

Mr. J. H. E. Waters, mining engineer, died at Denver, Colo., May 8.

Mr. James Owen has been reappointed Township Engineer of Montclair, N. J.

Mr. H. P. Morrison has been appointed engineer for roads in Richmond County, N. Y., vice Mr. W. S. Bacot.

Mr. F. A. Dunham has been appointed engineer in charge of the construction of the pavements at Fredonia, N. Y.

Mr. O. Burlingame, of Menominee, Wis., has been elected City Engineer of Racine, Wis., vice C. H. Kohlmann, deceased.

Mr. R. Walter Creuzbar has resigned his position with the New York Central R. R., and is now Assistant Engineer in the Finance Department of the city of New York.

Mr. John Chamberlain, Engineer of the Kentucky & Indiana Bridge Co., has resigned to take a similar position with the Richmond, Nicholasville, Irvine & Beattyville R. R.

Mr. Wm. C. Jewett, M. Am. Soc. C. E., has resigned the position of Resident Engineer of the Cincinnati, New Orleans & Texas Pacific Ry. (Cincinnati Southern Ry.), which position he has held for seven and a half years.

Mr. Alex. R. McKim has resigned his position as engineer for the East Berlin Iron Bridge Co., East Berlin, Conn., to accept the position of engineer on high building construction with J. B. & J. M. Cornell, of New York city.

Mr. F. H. Thomas has been appointed Superintendent of the Bellefonte Central R. R., with office at Bellefonte, Pa., vice Mr. Thos. A. Shoemaker, resigned to accept the position of General Manager of the Bellefonte Furnace Co.

Mr. J. C. Slocum, of Chicago, has formed a partnership with Mr. F. H. Prentiss, of Boston, formerly manager of the New York Steam Co., and has removed his offices to the Monadnock Building. The firm carry on a general practice in engineering, making a specialty of electrical and mechanical engineering.

NEW PUBLICATIONS.

EAST RIVERSIDE IRRIGATION DISTRICT: Report of Chief Engineer F. C. Finkle, President W. H. Robinson and other officials. 8vo; pp. 48.

This district is one of the many organized under the Wright law for the purpose of enabling the landowners to co-operate in securing a water supply. The district is near both the cities of San Bernardino and Riverside, Cal., and at the time of the report comprised 3,100 acres of land. The irrigation works of the district, and their construction, are described by the engineer, Mr. Finkle, and specifications are included for a 30-in. steel conduit and concrete reservoirs. The pipe lines of the Vivienda Water Co., together with the other irrigation works in San Bernardino Co., Cal., were described in Engineering News of July 4 and 25, 1891.

GRAPELAND IRRIGATION DISTRICT: Report on Its Physical and Engineering Problems and Business Status, with a Brief History of Its Organization and Confirmation. By F. C. Finkle, Chief Engineer of the District. 8vo; pp. 58; four folding and four full-page plates.

The contents of this report are well indicated by its title, given above. The district comprises 10,600 acres, and was organized in 1890, from which time until August, 1892, surveys and negotiations for a water supply were under way. The engineer's estimate of the cost of a tunnel 2,850 ft. long, for the development of water, 8,900 ft. of main canal and 65 miles of distributing ditches, is $134,900.

The photographic reproductions include views of an elevated reservoir, peach drier, vineyard and residence. The line drawings show the proposed tunnel, ditch and distributing lines, in plan, with sections of a timbered and concreted section of the tunnel, and of the ditch lined with stone in cement, and plastered with the latter.

WATER CONSERVATION IN NEW SOUTH WALES: Progress Report, H. G. McKinney, M. Inst. C. E., Commissioner in Charge of the River Murray and Chief Engineer for Water Conservation. Quarto: pp. 30; large folding maps and folding plates of diagrams.

This is the first annual report, in connection with work started in the middle of 1890 for a systematic study of water conservation in New South Wales in its relation to the water supply for domestic purposes and live stock, irrigation, mining and manufacturing. It appears that irrigation in this part of Australia was still in its infancy when the report was made. Several schemes are outlined.

Diagrams are presented showing the results of monthly gagings at five points on the River Murray, for the twelve years 1879 to 1890, and of the Darling and Macquarie rivers, each at one point, for the six years 1885 to 1890.

An interesting diagram shows the silting up of the bed of the River Murray from June 11, 1886, to April 16, 1890, which at the deepest point had filled the river 10.78 ft.

GRAVITY RESEARCH. Determinations of Gravity with Half-Second Pendulums. By T. C. Mendenhall. 8vo; Pub. Doc.; pp. 62.

This is an exceedingly interesting and complete presentation of this highly technical subject. Any one interested in science can read it both with understanding and interest. It is one of the many evidences of the immense amount of good scientific work done at government expense.

THE CONSTRUCTIVE MATERIALS OF ENGINEERING. By Albert W. Smith, Prof. Mech. Eng., Leland Stanford, Jr., University. 12mo; pp. 82. 25 cents.

This is apparently intended as a work to be used in lieu of manuscript or lithographed notes for college lectures. It seems to contain as much information on its subject as can be put into 82 small pages; but how much is that for such a subject? We shall review the general expediency of this kind of college pemmican in our current articles on the "Ideal Engineering School," and therefore will not rediscuss it here. There is much to be said for it; there is also much to be said against it.

TABLES OF SQUARES FROM 1 TO 10,001. Rochester Bridge & Iron Works, Rochester, N. Y. 8vo; blueprints; pp. 49. $1.

That the enormous labor of computing and blue-printing, in manuscript, a table of squares to 10,000 should have been undertaken shows that there is great need of such a table among bridge engineers; but it seems a pity that such a laborious work should have been done when "Barlow's Tables," giving squares, cubes, square roots, cube roots and reciprocals of all numbers to 10,000 exists, and has been in print for 50 years, and can be had for $2. Those tables, moreover, possess the advantage of having been so long before the public, and so accurately computed in the first place, that they are now, with reason, believed to be practically free from error. The compilers of this manuscript table announce that it has been computed and checked by independent methods, and is believed to be free from error; but it requires an almost superhuman carefulness to have so extensive a manuscript free from error. We fear the labor of making it would never have been undertaken had the compilers known of "Barlow's Tables."

THE HEATING OF LARGE BUILDINGS. By Alfred R. Wolff, M. E., Consulting Engineer, 907 Fulton Building, New York. Pamphlet; 8vo; 16 pp. $0.25.

This is a reprint of a lecture delivered before the Franklin Institute, of Philadelphia, and printed originally in the "Journal" of that institution. In it Mr. Wolff shows by text, diagrams and tables the amount of heat transmitted per square foot of surface per hour for various types of construction, the value of radiating surfaces, the effect of electric lighting upon heating and ventilating problems, etc.

HAND-BOOK OF THE AMERICAN REPUBLICS. No. 3. 1893. Issued by the Bureau of the American Republics, Washington, D. C. 8vo; paper; pp. 604; with maps and illustrations.

This edition of the hand-book, corrected to January, 1893, contains about 120 more pages of general information than did hand-book No. 2, issued in February, 1891. But, like its predecessors, it is devoted to the statistics and trade relations with the countries of Central and South America. The additional matter, aside from corrected statistics for a number of the states, consists of a detail of the reciprocal commercial arrangements with the United States, covering about 78 pages, and the increase of exports from the United States to Latin-America, covering the period 1885-1891. The latter chapter shows an increase from $61,787,949, in 1885, to $87,879,124, in 1891, or $26,091,175 in all.

A MANUAL OF MACHINE DRAWING AND DESIGN. By David Allen Low, M. Inst. M. E., Head-Master of the People's Palace Day Technical School, London; and Alfred William Bevis, M. Inst., M. E., Director of Manual Training to the Birmingham School Board. London and New York: Longmans, Green & Co. 8vo; cloth; 375 pp.; very fully illustrated. $2.50.

After commencing with some very sensible and practical points as to the paper and instruments to be used and the manner in which drawings should be made, colored, figured and lettered, the authors follow with a concise statement of the various principles of mechanics, and the materials used in construction, illustrating with examples worked out. The subject of screws, bolts and nuts is then taken up in great detail, with tables of dimensions, formulas and excellent dimensioned drawings. Cotters, pipes and pipe-joints, shafting, and their couplings and supports, belt and rope gearing, etc., are next taken up in successive chapters, treated in similar detail and fully illustrated. Every part of an engine and its boilers is, in fact, handled in succession, until the final chapter deals with the triple-expansion type of this machine. The treatment is progressive, the text is concise and plain, and a decided feature of the work is the excellent manner in which the text is illustrated by reproductions of dimensioned shop drawings. While it is excellently adapted for the use of students, it is also full of practical workshop hints and suggestions which make it quite as valuable to those who are already in active practice.

WYOMING EXPERIMENT STATION: Meteorology for 1891, Bulletin No. 4, December, 1891, By B. C. Buffum. pp. 194; illustrations. Soils of the Agricultural Experiment Farms, Bulletin No. 6, May, 1892. By J. D. Conley, Geologist and Chemist, and E. E. Slosson, Assistant Chemist. pp. 24. Irrigation and Duty of Water, By Prof. B. C. Buffum, Bulletin No. 8, October, 1892. pp. 31; illustrations.

The Wyoming Experiment Station is located at Laramie, and is an adjunct of the Agricultural College Department of the University of Wyoming. There are five sub-stations in different parts of the state.

An important part of the work of this station relates directly or indirectly to irrigation. The bulletin on meteorology describes, briefly, the instruments used at the station, and presents views of the same. Statistics of temperature of both air and soil, precipitation, evaporation, wind, atmospheric pressure and terrestrial radiation are given in the bulletin.

Mechanical and chemical analyses of soils at the several stations are presented in the bulletin on that subject, and are of interest in connection with the scientific study of sewage disposal by irrigation or intermittent filtration.

The bulletin on "Irrigation and the Duty of Water" is largely compiled, its author states, from other writers, with additional matter suggested by observation and experiment. The general theory and practice of irrigation seems to be as thoroughly reviewed as is consistent with the 22 pages of space given to the subject. Results of observations on the duty of water, made in 1891 and 1892, at the Laramie and Wheatland experimental farms, are given, which show a variation of from 95.6 to 735.3 acres for a continuous flow of 1 cu. ft. per sec.; the first having been for a "mixed crop," and the second for corn. Illustrations are presented to show the Mead Wyoming nilometer, a trapezoidal weir, weir-box and nilometer, used at the Laramie farm and Carpenter's water register.

TRANSACTIONS OF THE ASSOCIATION OF ENGINEERS OF VIRGINIA. NO. 2: Roanoke, Va.; 8vo.; pp. 165, illustrated.

This volume contains the papers presented for July, 1891, to March, 1893, together with the address made by the president at the Richmond meeting, in July, 1892. The papers are as follows: "The Methods Used in the Official Survey of Roanoke, Va.," Geo. P. Wood; "Steam Boiler Explosions," C. G. Cushman; "Specifications of First Class House Wiring for Electric Light," Robert Cummings; "Use of Steel for Rivets," J. H. Fitts; "Public Highways and Roads in Virginia; Their Construction and Maintenance," Oscar Saabye; "The Necessity of Co-operation by American Engineers," I. W. Draper; "Easement Curves," C. H. Rice; "A National Railway School," Herman Crueger; "Iron Coal Pier at Norfolk, Va.; N. & W. R. R.," W. W. Coe; "Historical Notes Upon the Work of the First Mining Engineer of the Colony of Virginia," W. H. Adams; "The Stadia and Its Uses in Topographical Surveys," E. A. Herring; "A Plea for the Establishment of a United States Weather Signal Station at Roanoke, Va.," C. S. Churchill; "Locomotive Tests," G. R. Henderson; "Report of Committee on the Common Roads of Virginia; "Heating and Ventilation," R. P. C. Sanderson; "The Construction of Theatres from an Optical Point of View," R. de Saussure.

LA NAVIGATION AUX ESTATS-UNIS. Par H. Vetillart, Ingenieur en Chef des Ponts et Chausees. Rapport de Mission. Renseignements Historiques, Financiers, Descriptifs et Statistiques sur les Ports et les Voies Navigables. Paris, Imprimerie Nationale. 1892. Quarto; no illustrations, 544 pp.

The above very detailed report upon the waterways of the United States is sent us by the Minister of Public works, at Paris, through the Smithsonion Institution, and embodies the work done by a member of the French delegation to the International Marine Congress held in Washington toward the end of 1889. A map showing the channels described is now in press and will shortly appear. In so voluminous a work little more can be done here than to outline the ground covered by its author and compiler. The first part treats in separate chapters of the origin and principles of the government authority over ways of communication, commencing with the Constitution of 1789; lighthouses; natural navigable streams, ports and harbors; the routes followed; artificial waterways or canals; railways and a general resume of this part. The second and fullest part deals with the description, statistical and financial elements of the subject under discussion. These tables, while they are great in number, are by no means well filled out, for reasons which any one will

understand who has attempted to compile similar information in a limited time. Nevertheless, an immense amount of information has been gathered together, more than sufficient to attest the laborious character of the work performed by M. Vetillart. As is usual in many government publications much space has been wasted in the arrangement of these tables.

MODERN OFFICE BUILDINGS. Practical Limiting Conditions in Their Design. By George Hill, M. Am. Soc. C. E. 44, 46 Broadway, New York. Pamphlet reprint from "Architectural Record"; pp. 20, with diagrams.

In this paper Mr. Hill points out and considers the elements that combine to make a successful modern office building. Each of these elements is treated in detail with great clearness. Floor plans are given for buildings covering areas verying from 25×100 ft. to 100×100 ft. The method of construction is then discussed and tables follow giving the following comparative data for each of the designs presented—for buildings ranging in height from 6 to 20 stories; the wall areas in brick and in steel and the cost of building and of lot for both types of construction. A final table gives the cost per sq. ft. of lot for buildings from 1 to 20 stories high, and covering lots 25×100 ft., 50×100 ft. and 100×100 ft. It is a very practical paper throughout; and as the author promises to more fully treat the subject in a forthcoming book those interested can fairly expect an exceedingly useful treatise based upon the latest practice.

TYPEN FUER WALZEISEN. Bericht des vom Oesterreichischen Ingenieur und Architekten Vereine eingesetzten Comites zur Aufstellung von Typen von Walzeisen, by Johann Buberl, Inspector of the Austrian Northwest Railway. 4to, pp. 38, illustrated; 33 plates. Vienna, 1892. Verlag des Oesterreichischen Ingenieur und Architekten Vereines. Price, postage paid, $1.25.

This is an enlarged edition of the "Standard Cross Sections for Wrought Iron," submitted by a committee of the society mentioned. It contains about 400 full size cross sections, applying to structural iron work, bridge and ship building and industrial uses in general. In this edition are included a great number of types of cross sections, which as yet have not been produced in Austria, but are supplied by importation. This work has been carefully compiled and the plates are excellently engraved.

STATE BOARD OF HEALTH OF NEW JERSEY: Report for 1892; and Report of the Bureau of Vital Statistics. 8vo; pp. 590; tables. E. M. Hunt, M. D., Secretary.

Among the special papers in this report the most interesting to engineers is one by the Secretary, entitled "To What Extent Do Streams of Water that Receive Sewage Purify Themselves?" in which some of the recent discussions on this subject are reviewed, and it is concluded, among other things, that all water supplies should be inspected for, say, 30 miles above water-works intakes, and that, as a rule, sewage from towns should be purified before entering streams used as water supplies.

Mr. A. Clark Hunt, M. D., contributes a paper on "Water Supplies," principally relating to New Jersey sources, and works recently built in the state. A popular paper by Prof. C. McMillan, on "Some Points Connected with Sewer Lettings and the Construction of Sewers," is also included.

STATE ENGINEER OF WYOMING: First Biennial Report, 1891 and 1892. Elwood Mead State Engineer. 8vo; pp. 82 and lxxi.; eight folding maps.

This report contains an outline of the status of irrigation in Wyoming and the work of the state enneer, the latter being illustrated by the folding maps. Of the maps, one is of the state, four of the four water divisions into which the state is divided, and three show drainage and canal systems of small sections of the state, as plotted from surveys for the purpose.

GAS AND ELECTRIC LIGHT COMMISSIONERS OF MASSACHUSETTS: Report for 1892. 8vo; pp. 228; many tables. Wm. M. Olin, Secretary.

Without doubt this is the largest and most complete collection of statistics relating to gas and electric lighting plants ever published. There are included in the report statistics regarding the finances, operation and schedules of rates of 136 plants, 26 of which supply both gas and electric light, 63 electric light and 47 gas only.

THE PURIFICATION OF DRINKING WATER BY SAND FILTRATION: Its Theory, Practice and Results; with Special Reference to American Needs and European Experience. By Wm. T. Sedgwick, Professor of Biology, Massachusetts Institute of Technology, Boston, and Chief Biologist to the State Board of Health of Massachusetts. Reprinted from the "Journal of the New England Water-Works Association." Vol. VII., No. 2. 8vo; pp. 28, and appendix, 13; 10 figures and 9 plates.

The present interest in water purification makes the publication of this excellent paper very timely. The paper was read nearly a year ago before the annual meeting of the New England Water-Works Association, and a summary of it was given in our issue of June 16, 1892. The filter beds of Berlin are described in some half a dozen pages, and those of Warsaw, (Russia), Oporto, Zurich, Rotterdam and London more briefly. The theories and opinions regarding filtration of the two Germans Professor Fraenkel, a bacteriologist, and Mr. Piefke, the resident engineer in charge of one division of the Berlin water-works, are presented briefly, but clearly.

The appendix is a reduced fac-simile of the monthly report for May, 1892, on the condition of the Metropolitan (London) water supply, and contains detailed statistics relating to the water supply of London, including the filtration works, and also the results of chemical analyses.

WATER-WORKS REPORTS.—The following water-works reports have been received, the names given being those of superintendents unless otherwise stated:

Concord, N. H., V. C. Hastings. Manchester, N. H., Chas. K. Walker. Foxborough, Mass., reports on construction, F. L. Fuller, Engineer, Boston. Haverhill, Mass., Jas. A. Huntington, Secretary. Holyoke, Mass., John D. Hardy. Lowell, Mass., R. J. Thomas; C. L. Knapp, Clerk. Hartford, Conn., Ezra Clark. Poughkeepsie, N. Y., Chas. E. Fowler. Atlanta, Ga., W. G. Richards. Madison, Wis., John B. Heim.

TRADE PUBLICATIONS.

THE WORTHINGTON WATER METER.—Henry R. Worthington, New York city. 12mo; pp. 32.

This little pamphlet describes the Worthington meter and its applications to hot and cold water, oil, naphtha, etc. Some convenient tables are also presented.

HOISTING PLANT.—Lidgerwood Mfg. Co., New York. 4to; pp. 114; illustrated.

This is a comprehensive catalogue and price list of various types of hoisting engines for all kinds of work, including electric hoists. The Locke-Miller cableways and the rapid unloader for ballast trains are among the company's specialties, and have been illustrated and described in our columns. Boilers, engines and general supplies are also furnished by the company.

SOCIETY PROCEEDINGS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the meeting held May 3, Mr. William Metcalf, President, in the chair, the paper by H. D. Whitcomb, on "The Improvement of the James River, Va.," was read by the Secretary, as noted in our issue of May 4. The discussion was mainly in reference to the value of dredging in streams with sedimentary beds. The views expressed were that dredging often more than pays for itself, even where it gives but temporary improvement, and that it often depends upon the regulation of the currents by main walls, etc., as to whether it will afford any permanent channel.

At the meeting on May 17, a paper by J. W. Schaub, on "The Detroit Union Depot Viaduct," was presented. In 1890 the Fourth Street Union Depot Co., of Detroit, Mich., was incorporated by four railway companies, namely, the Wabash, the Canadian Pacific, the Flint & Pere Marquette, and the Detroit, Lansing & Northern, all entering the city of Detroit over various lines with widely separated termini. To facilitate the interchange of business and for other reasons, the company determined to build a union station with elevated approaches. To do this a three-track viaduct 4,000 ft. long was projected through River St. Mr. C. H. Ellis was appointed chief engineer, and prepared specifications and invited tenders. The contract was let to the Detroit Bridge & Iron Works, in January, 1891, and the work was completed in eight months. The live load assumed for each track was two 104-ton engines, followed by 3,000 lbs. per lin. ft.

The longitudinal force due to the friction between the rails and the wheels of two trains, each weighing 3,000 lbs. per lin. ft., moving in the same direction upon the outside tracks, was provided for. The coefficient of friction for this purpose was assumed at 20%, and to resist the force longitudinal bracing was provided for between the columns. This bracing went, in some cases, to the ground, but not usually, and when it did not the strain was taken up by means of flexure in the columns. A wind force of 750 lbs. per lin. ft. was assumed and provided for. This was taken as acting in a horizontal plane passing through the base of the rails, and to resist it transverse bracing was inserted between the columns. This, also, in some cases was carried to the ground, but generally it was not. The horizontal displacement of both dead and live loads due to wind was provided for in proportioning the columns.

The material in the superstructure is steel, except the bracing and anchorages, which are iron. The bearing plates are cast iron. The steel used is medium steel, excepting the rivets, which are soft steel. No shape iron or steel weighing less than 6 lbs. per lin. ft. was used; no web plates less than ⅜ in. thick, and no metal less than 5-16 in. thick. All holes were punched and reamed, and all sheared edges of web plates were planed. In steel, the working stresses per square inch were for tension flanges, 10,000 lbs. (net) and compression flanges were given the same gross area as the tension flanges.

In no case did the combined stresses in the columns from wind or friction exceed 12,000 lbs. fiber strain per sq. in. on the outer fibers. Shearing on rivets, 9,000 lbs.; bearing on rivets, 14,000 lbs. and field rivets only two-thirds of this. Bolts were mostly used for these field rivets. These were cut from cold rolled steel shafting, 15-16 in. in diameter, so as to tightly fit the holes, and were threaded and provided with a nut and washer at each end, and their value was taken as that of field rivets.

The salient features in the design were: 1. The absence of all adjustable members all bracing being riveted; 2, the form of expansion joints used for longitudinal girders; 3, the connections for anchor rods to columns; 4, the use of cast bearing plates for distributing the pressure on the masonry; 5, the form of the longitudinal bracing. Where no clearance was required under the structure, the bracing ran to the foot of the column. Over streets 14 ft. clearance was required. Expansion joints were provided every 150 ft. longitudinally. A deck traveler was used which handled a cross-girder weighing 50,000 lbs. at the end of booms, reaching out 80 ft. It was counterbalanced with 75 tons of pig-iron.

No special difficulties were encountered with the structure. A thin layer of cement was used to bring the cast bearing plates to a level, but the writer does not recommend thin layers of cement. They do not make a good bond with the coping stone, and soon crumble and wear away at the edges of the casting. Plaster of paris for such areas seems to promise well, for even in thin layers it makes a bond with the coping stone and sets rapidly. To retard its setting, a little lime can be added. The use of sheet lead is questionable. Ordinarily, the working pressures on the bearing plates are not sufficient to cause the leak to flow. Even where coping stones are dressed to a true level, and the columns placed in position, it is not unusual to find that they are not plumb, and some simple method must be found to remedy the evil and not delay the work. The question is an important one, especially where the direct bending in the columns is such a large factor.

The second paper for the evening was by Cyrus C. Babb, on "Rainfall and River-Flow." The futility of basing computations of discharge for any river upon the average monthly rainfall is now pretty well recognized, and a more certain method is desirable. The result of the gaging of any stream to be of value must cover considerable periods of time, usually beyond the limits, both as to time and financially, of the average engineer. The percentage of annual rainfall flowing into rivers is not well understood by most engineers; as, for example, in the design for certain works for irrigation as high as 60% of the rainfall was taken as the stream-flow, when one-half of it would have been nearer the truth.

The present paper seeks to bring out the facts as to the flow of streams as shown by the gagings of rivers in the United States. A method is given for estimating monthly discharges, based upon the percentages of annual run-off to rainfall, and for distribution by months of the entire flow by the year for different basins.

The first stream mentioned is the Connecticut River, which flows nearly south for 375 miles and drains 11,083 sq. miles; its course is through a glaciated region, and the valley contains a number of lakes and springs which regulate the discharge, reducing the intensity of floods and increasing the summer flow. The basin is hilly and even mountainous. The older rocks, granite, etc., are found in the mountains, while glacial drift, interspersed with bowlders, occurs in the valleys. Numerous rapids and falls occur throughout the course of the river. From its source to the northern boundary of Massachusetts, there is a fall of 1,830 ft. in 240 miles, or 7.6 ft. per mile. Thence, 135 miles to the mouth, the fall is 1.5 ft. per mile. In Vermont and New Hampshire, there are elevations from 4,000 to 6,000 ft.

The discharge measurements by the U. S. Engineer Corps cover a period from 1871 to 1879, and daily gage-height records are accessible from the end of 1885, and partial ones to the present time. Tables are given showing the results of these measurements. These cover the average rainfall by months and years, the average discharge and the percentage of discharge to rainfall. One of the columns gives the monthly run-off in inches; that is, if the total flow for the month were spread over a plain of the size of the drainage area at the point of measurement, it would cover that plain to the depth given in the tables.

Curves are given of these results. April and May are the flood months, although the maximum point is attained in July. For purposes of comparison, similar curves are shown for the Potomac River. Three maximum points occur in all the curves, namely, March, July and November. This coincidence is significant and cannot be considered simply a matter of chance.

Tables are given for the Sudbury, Croton, Neshaminy and Savannah rivers also. The basins of the last three are small; they cover, respectively, 76, 353 and 139 sq. miles of drainage area. The results are comparable with the larger streams.

Daily gage heights have been obtained on the Savannah River since 1875, and discharge measurements have been made by the U. S. Engineer Corps of the daily discharges for this period. Reliance can only be placed upon the computations since 1884. The Savannah River is formed by the junction of the Tugaloo and Seneca rivers, at Andersonville, Ga., and flows southeasterly to the sea. The total fall between Andersonville and Augusta is 400 ft. in 106 miles, or 4 ft. to the mile. Between Andersonville and Petersburg 288 ft. in 55 miles, or 5.25 ft. per mile. The drainage area is 7,294 sq. miles at Augusta.

An inspection of all the curves shows their character to be dependent upon the geographical positions of the respective rivers. The farther south rivers are, the more uniform are their curves. By individual years the reverse is the rule. The northern streams are characterized by an annual flood, gradually rising in March or April, reaching its highest level, and maintaining it for a few weeks, and declining through June and July, with low water for the rest of the year. The southern streams are subject to freshets throughout the year, rising to considerable heights and disappearing in a day or so. These differences are due to two causes, climatic and topographic The northern spring floods result from the melting of the winter snows, their intensity being controlled by the topography of the northern valleys through which they flow. In the southern valleys, however, a rainfall upon a watershed soon finds its way into the river channels; but for the entire year the percentage of rainfall is about the same for all.

For the three smaller basins the percentages of annual discharge to precipitation vary but slightly, averaging 40.7 per cent. For the Savannah, the average is 48.9 per cent. For the two larger rivers, the Potomac and Connecticut, the percentages are 53.0 and 56.5, respectively.

Another table gives data for a number of western streams. The use of the table is suggested as follows: If the average flow for a certain month for any stream be known, then taking from the table the percentages of the locality in which the stream occurs, its discharges for the other months and for the year may be obtained. Knowing the annual rainfall for a certain basin, taking the locality in which the stream occurs, the annual discharge can be obtained, and the monthly distribution follows. It is considered that more accurate results can be obtained from these figures than by figuring discharges from records of monthly rainfall.

The rainfall records for the western states are very unsatisfactory, and few records of precipitation in the mountains are in existence.

NEW ENGLAND RAILROAD CLUB.—At the meeting on May 10 Mr. Marden announced that the Fitchburg R. R. was building an air-brake instruction car, and would rent it at a reasonable rate to other roads when it was not in use at home. The subject for the evening's discussion was the desirability of having standard trucks and foundation brake gear for freight cars, and Messrs. Lauder, Adams, Marden and Ewing took part in it. There was a general agreement that the adoption of a standard truck would be of great benefit, provided the mechanical officers of the railway companies could be made to follow it absolutely. But, unless the higher officials of the railway companies will make a general agreement to adopt and adhere to standards, and will compel the heads of their mechanical departments to live up to them, there seems little chance of a standard freight car-truck coming into general use. As to what such a standard truck should be, the discussion showed decided differences of opinion. Between the rigid truck and the swing-motion truck, it appeared that the former was much cheaper to build, inspect and maintain, but the latter rode easier over rough track, and was preferable for high-speed trains. Under the present system of car interchange, however, there is no object for a road to spend money to build a better running truck, or better car than its neighbors, as the benefit accrues to the railways as a whole and not to the especial railway which owns the car. As to the difficulty of maintaining standards once adopted, Mr. Kolseth, of the Westinghouse Air Brake Co., made the following remarks:

Some four or five years ago the Westinghouse Co. adopted a standard lever and pin. The M. C. B. Association took up the matter, and increased the sizes which the company recommended, thereby increasing the wearing surface. I have found within a month a car running into Boston that had the company's brake and the standard holes in the Westinghouse equipment, but a 9-16-in. pin. The pin was doubled up. With a pin of that size in a 1-in. hole there would be about 1½-in. movement on each beam that is taken up by the piston travel before the brake is applied at all, and you cannot take up the slack of the brake without excessive piston travel. There is no use of having a standard if even the master car builders of New England will not follow it closer than that. Six months ago I was called upon by a certain road where some new cars were to be built and equipped with the air-brake. In looking over the brake rigging, I found that the levers were of the right proportion with regard to the weight of the car, but the lever and pin were too small, having been made before the standard was adopted, and I called their attention to the fact.

They had let out their order to an outside party to make the levers and pins, and I went to that party and told him they must be standard. I went to the road again in about three months, to see that the brake was all right; the brake rigging was all there, but I was surprised to find that the levers were just the same as they were on the old cars. They had sent a car for a sample, and the General Manager had ordered 50 or 100 cars to be built exactly like that, and in consequence they built the levers the same as on that car, without regard to whether they were right or wrong. If you adopt a standard and do not follow it more closely than that I don't think it will benefit you much.

It was voted to hold no meetings of the Club in June, July or August, except as summer excursions may be arranged for by the Executive Committee.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The annual meeting for the reception of the yearly reports, the election of officers, and other business proceedings, was held at the headquarters of the Institute, 12 West 31st St., New York, May 16. At the general meeting on May 17 the following papers were read: "The Behavior of Fuse Metals in Direct and Alternate Current Circuits," Charles P. Matthews; "A Modified Deprez D'Arsonval Galvanometer," Lieut. Charles D. Parkhurst; "The Variation in Economy of the Steam Engine Due to Variation in Load," Prof. R. C. Carpenter; "An Automatic Printing Speed Counter for Dynamo Shafting," Prof. Geo. S. Moler; "Practical Aspects of Electrical Resonance," by Dr. M. I. Pupin; "The World's Electrical Congress of 1893," Discussion of the provisional program prepared by the Institute committee; "A New Method and Apparatus for Measuring Conductivity," Mr. E. G. Willyoung; "The Heating of Armatures," A. H. and C. E. Timmerman.

LIVERPOOL ENGINEERING SOCIETY.—Annual general meeting was held May 10, when an adjourned discussion took place upon the paper read at a previous meeting by Mr. Ernest W. Pierce, Assistant Solicitor to the Liverpool Corporation, entitled: "Engineering Contracts."

SOCIETL OF NAVAL ARCHITECTS AND MARINE ENGINEERS.—This society has been incorporated under the laws of this state. The purpose of the society is to promote the arts of shipbuilding and marine engineering, and, in furtherance of this object, to hold meetings for social intercourse, and the reading and discussion of professional papers, to be published. It is expected that the first meeting will be helding the autumn. The incorporators are: William H. Webb, Charles H. Cramp, George E. Weed, H. Taylor Gause, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Clapps, Edwin D Morgan, George W. Quintard, Harrington Putnam and Jacob W. Miller.

The officers for the first year are as follows: President, Clement A. Griscom, Philadelphia; Secretary, Washington L. Capps, Bureau of Construction, Navy Department; Council: Francis T. Bowles, Norfolk, Va.; H. Taylor Gause, Wilmington; Charles H. Loring, New York; Lewis Nixon, Philadelphia; and Harrington Putnam, New York.

ENGINEERS' SOCIETY OF PHOENIXVILLE.—The last meeting of the season was held April 25, Mr. Wagner, president, in the chair. Mr. Samuel Tobias Wagner read a paper on "Iron and Steel in Tension." Owing to the limited time allowed, only the effect of a tensile stress on iron and steel was considered. Previous records of tests are only of comparative value, and when the strength of a certain material is to be ascertained tests must be made. The early literature of testing was briefly passed over with mention of the names now famous for their experimental research. Testing machines were described as far as the motive power used was concerned, viz.: 1, Direct lever; 2, screw and gearing; 3, hydraulic power. Major Wade made the first machine for the U. S. Government in 1856, and this was subsequently improved by Captain Rodman.

The following capacities of the large full-sized machines in America were given as follows: The Phoenix Iron Co.'s machine, at Phoenixville, Pa.; the largest in the world; ultimate capacity, 2,160,000 lbs.; length of longest bar, 45 ft., with 15% stretch; described in Engineering News, Jan. 10, 1891.

The Union Bridge Co.'s machine, at Athens, Pa.; ultimate capacity, 1,244,000 lbs.; length of longest bar, 40 ft., with 12% stretch; described in "Trans. Am. Soc. C. E.," Vol. XVI.

The U. S. government machine at the U. S. Arsenal, Watertown, Mass.; ultimate capacity, 1,000,000 lbs.; length of longest bar, 30 ft.

The Edge Moor Bridge Co.'s machine, at Edge Moor, Del.; ultimate capacity, 700,000 lbs.; length of longest bar, 35 ft.

The Keystone Bridge Co.'s machine, at Pittsburg, Pa.; ultimate capacity, 600,000 lbs; length of longest bar, 30 ft.

Tensile tests are ordinarily made because other kinds of stress bear a more or less definite relation to them, and they are the easiest made. The following points are necessary to secure an accurate and reliable tensile test: 1. The shape of the specimen must be such as to give a correct record of the strength; 2. the readings of the machine should be accurate, and the test piece pull perfectly straight; 3, accurate measurements should be made of all dimensions, and to the time occupied in making the test. The terms elastic limit, ultimate strength, elongation and reduction were defined, and the first three properties show graphically on a curve diagram. The cracking of the scale in steel was mentioned as an accurate method of determining the elastic limit.

The short, grooved, old-fashioned test piece was described, and its bad points explained. Records were shown, indicating the great discrepancies between long and short specimens. The electric contact micrometer was described as an accurate instrument for determining the stretch below the elastic limit, and for making measurements for calculating the modulus of elasticity. Forms were shown for recording records of specimen and full-sized tests, and particular points which should be noted were pointed out. Records of characteristic tests of mild, rail and spring steel were shown, and characteristic features of iron and steel were exhibited by means of specimens. The usual bending, quenching and driving tests were described, and samples shown. Records of several full-sized eyebar tests were read, and a form used by the Phoenix Iron Co. shown.

The next meeting will be in September.

W. Halliburton, Secy.

AMERICAN INSTITUTE OF ARCHITECTS.—The date fixed for the annual meeting of the American Institute of Architects is the week beginning July 31, 1893, in conjunction with the International Congress of Architects, which is to be held in the World's Congress Art Palace, situated on the shore of Lake Michigan, in the heart of the city of Chicago.

It is proposed by the Institute to have a series of papers read by the master artists who have been engaged upon the work at Jackson Park, and this time we are promised papers by Daniel H. Burnham, Chief of Construction; Frederick Law Olmsted, Landscape Architect; E. C. Shankland, Chief Engineer, and W. H. Holcomb, General Manager, and expect favorable replies from several others.

Alfred Stone, Secy.

COMING TECHNICAL MEETINGS.

NEW YORK RAILROAD CLUB.
May 18. Secy., H. G. Prout, 73 Broadway, N. Y.
ENGINEERS' CLUB OF PHILADELPHIA.
May 20. 1122 Girard St., Secy., L. F. Rondinella.
SWEDISH ENGINEERS' CLUB.
May 20, Secy., P. Valentine. At 231 Union St., Brooklyn, and 646 North 10th St., Philadelphia. At 180 La Salle St., Chicago. Secy., John Ericson.
DENVER SOCIETY OF CIVIL ENGINEERS.
May 23. Secy., F. E. King, Jacobson Block.
CENTRAL RAILWAY CLUB.
May 24, Secy., S. W. Spear, Buffalo, N. Y.
CANADIAN SOCIETY OF CIVIL ENGINEERS.
May 26. Secy., C. H. McLeod, Montreal, P. Q.
ENGINEERS' CLUB OF MINNEAPOLIS.
June 1. Secy., E. Nexsen, 504 Kasota Block.
ASSOCIATION OF CIVIL ENGINEERS OF DALLAS.
June 2. Secy., E. K. Smoot, 906 Commerce St.
TECHNICAL SOCIETY OF THE PACIFIC COAST.
June 2, Secy., O. Von Geldern, 719 Market St., San Francisco.
ENGINEERS' CLUB OF ST. LOUIS.
June 7. Secy., Arthur Thacher, Odd Fellows' Building.
AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 7. Secy., F. Collingwood, 127 East 23d St., New York.
WESTERN SOCIETY OF ENGINEERS.
June 7. Secy., Jno. W. Weston, 51 Lakeside Bldg., Chicago.
ENGINEERS' AND ARCHITECTS' CLUB OF LOUISVILLE.
June 8. Secy., F. W. Mowbray, Norton Building
ENGINEERING ASSOCIATION OF THE SOUTH.
June 8. Secy., W. G. Kirkpatrick, Nashville, Tenn.
MONTANA SOCIETY OF CIVIL ENGINEERS.
June 10. Secy., G. O. Foss, Helena.
ENGINEERS' CLUB OF KANSAS CITY.
June 12. Secy., Waterman Stone, Baird Building.
WISCONSIN POLYTECHNIC SOCIETY.
June 12. Secy., M. F. Schinke, City Hall.
ATLANTA SOCIETY OF CIVIL ENGINEERS.
June 13. Secy., Parker N. Black, Capitol Block, Atlanta, Ga.
CIVIL ENGINEERS' CLUB OF CLEVELAND.
June 13. Secy., F. C. Osborn, Case Library Bldg.
NORTHWEST RAILROAD CLUB.
June 13. Ryan Hotel, St. Paul. Secy., W. D. Crosman.
NORTHWESTERN SOCIETY OF ENGINEERS.
June 13. Secy., D. W. McMorris, Burke Block, Seattle, Wash.
MASTER CAR BUILDERS' ASSOCIATION.
June 13. Lakewood, N. Y. Secy., J. W. Cloud, Buffalo, N. Y.
CIVIL ENGINEERS' ASSOCIATION OF KANSAS.
June 14. Wichita, Kan.
ENGINEERS' CLUB OF CINCINNATI.
June 15. Secy., J. F. Wilson, 24 W. 4th St.
SCANDINAVIAN ENGINEERING SOCIETY OF CHICAGO.
June 15. Secy., C. F. Franson, Portland Block.
TACOMA SOCIETY OF ENGINEERS AND ARCHITECTS.
June 16, 201 Washington Building.
NORTHWESTERN TRACK AND BRIDGE ASSOCIATION.
June 16. Secy., D. W. Meeker, St. Paul.
AMERICAN RAILWAY MASTER MECHANICS ASSOCN.
June 19. Lakewood, N. Y. Secy, Angus Sinclair, New York.
COLUMBIAN ENGINEERING SOCIETY.
June 20. Secy., F. W. Hart, Washington, D. C.
ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
June 20. Secy., R. H. Clark, Pittsburg.
BOSTON SOCIETY OF CIVIL ENGINEERS.
June 21. Secy., S. E. Tinkham, 36 Broomfield St.
NEW ENGLAND RAILROAD CLUB.
Sept. 13. Secy, F. M. Curtis, O. C. R. R., Boston.
ENGINEERS' SOCIETY OF PHOENIXVILLE.
Sept. 5. Secy., W. Halliburton.
WESTERN RAILWAY CLUB.
Sept. 19. Secy., C. F. Street, Rookery Building, Chicago.
ASSOCIATION OF ENGINEERS OF VIRGINIA.
Sept. 20. Secy., L. V. Carmalt, Roanoke, Va.
CIVIL ENGINEERS' SOCIETY OF ST. PAUL.
Oct. 2. Secy., C. L. Annan, City Engineer's Office.

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We publish in another column the first part of the graduating thesis which received the third of the prizes offered by Engineering News for the best theses submitted by engineering graduates in 1892. The thesis was the work of two students of Sibley College, Cornell University, Mesars. Joseph Kuhn and Robert T. Mickle.

As we have before announced that all theses receiving prizes would be published in full, it is necessary to explain the reasons why we omit the publication of the second-prize thesis, that by Mr. John E. Moore, entitled "Losses in Iron Under Alternating Magnetic Forces." After the result of the competition was announced, we learned from Mr. Moore that he had furnished the substance of his thesis for publication in one of the electrical journals, his action being taken in ignorance of the conditions under which the prizes were offered. He made ample apology to us for his mistake and voluntarily returned the prize money.

To guard against similar mistakes in this year's competition we shall send out about June 1 blank certificates covering the essential conditions of the competition, which can be filled out by the professors in sending in theses.

A Senate Committee on Agriculture and Forestry has been instructed by Congress to investigate the conditions of the agricultural interests throughout the United States, and to ascertain the causes and to suggest remedies for any depression that may be found. This committee has appointed sub-committees to consider matters relating to the cultivation of cotton and wheat, and in a letter to this journal Mr. Albert A. Pope, of Boston, strongly urges that another sub-committee take up the relation of country roads to the agricultural interests. While we cannot quite agree with Mr. Pope in his suggested road department at Washington, for reasons already given, we heartily commend his present suggestion. Mr. Pope has done much effective work in the prevailing movement for better roads; and if we do have a systematic road exhibit at the World's Columbian Exposition, as now seems probable, it will be largely due to his personal zeal and untiring interest in this subject, and to the efforts and financial aid of the National League for Good Roads. In his petition to the United States Senate concerning the condition of roads in the farming district he says that perhaps one of the most potent factors in the depression in agricultural interests is the wretched condition of the roads in these districts. The winter and spring, when fieldwork is impossible and man and beast are idle are the favorable seasons for the transport of products to the nearest market; but under prevailing conditions the farmer and his horses are forced to remain at home in idleness, awaiting a season when roads are passable, but when much other work is also demanding their united services. Improved roads available at all seasons of the year may thus well mean the difference between profit and loss in the disposal of farm produce.

At the National Farmers' Congress held at Lincoln, Neb., in November, 1892, it was stated that economical road improvement throughout the country would result in an annual saving of $250,000,000 in the hauling of these products alone; and while it is impossible to say just what this saving would be, the Massachusetts Highway Commission, as the result of careful examination, puts the annual loss to that state from bad roads at $5,000,000, and further says that this sum properly expended would put all the principal highways of Massachusetts in good condition. Scientific road construction often costs less than the building of a bad road, and the maintenance of the properly constructed road really amounts to much less than the sums annually spent in the attempt to make bad roads passable. With these conditions, the truth of which no intelligent investigator can deny, it is high time that the farmers, who nominally make the roads and actually use them—when they can—should awake to the realization of facts that have a most important bearing upon their own interests. It is the farming community that is most affected by a system of bad roads, and it is the one class slowest to appreciate the advantages of improved conditions. It is eminently proper, therefore, that the Senate committee now investigating the general interests of this class should also seriously consider the question of bad roads and their effect upon the agricultural districts. Their verdict, whatever it may be, should be based upon the fullest possible data and careful, unbiased investigation; and when made it should be given the widest publicity. It could not fail to sow good seed and to give an impetus to a movement exceeded by none in its national importance.

In his presidential address at the Montreal meeting of the American Institute of Mining Engineers, Mr. John Birkinbine took as his subject the development of technical societies in the United States and abroad. While the history of these organizations is interesting, the chief point of interest to engineers in this address was the sound advice given concerning the method of presenting and publishing technical papers, which has already been commented upon in our issue of March 9. As Mr. Birkinbine says, the discussions which follow the presentation of the majority of these papers are often more valuable than the papers themselves. As a rule they bring out information from personal experience that the original does not contain, and that would only come to light as a discussion by some one who may be a careful observer but lacks the time or inclination to write out what he knows. Some papers do not invite discussion, by reason of their intensely mathematical or other technical form; but these papers should never be read, except in abstract, at a congress or meeting of engineers. They consume valuable time, shut off discussion on more generally interesting papers, cannot be readily digested, and are, in fact, a nuisance to the enforced listeners. The practice now prevailing in a number of technical societies, of printing the paper in advance, or at least an abstract of it, is to be commended from every standpoint. By so doing the greatest time is permitted for oral discussion, which is always more interesting and attractive, and important points, omitted in the written paper, are often brought out under the spur of personal contact and an interchange of ideas and experiences. The results are more practically valuable to the engineers as a body, for they are the combined opinions of many men on some particular subject rather than the unchallenged statement of one man as presented in a long paper which gives no time for discussion. We fully agree with Mr. Birkinbine in his remark that a few papers thoroughly discussed are more valuable for publication and preservation than a great mass of material offering controversial data without discussion.

Quantity is no measure of the value of the papers or the importance of the topic discussed, as Mr. J. G. Blaine pointed out in writing on the growth of Congressional debates. For the 50th Congress, says this statesman, a Congress covering the uneventful period of 1887-89, the printed pages of proceedings were greater in number than those covering the whole period of the Civil War, with all its mighty issues at stake. When the subject is interesting and the topic a live one, men talk on their feet and take their text from personal conviction and experience and not from books. The matter may not be so elegantly expressed, nor the sentences so beautifully rounded, but the substance is generally much more useful and interesting to the listeners, especially when this audience is made up of men engaged in similar pursuits. Written papers are, of course, necessary, and much valuable data can only be presented in this way, but everything should be done to invite and provoke discussion in papers permitting it; and at meetings, the minimum of time should be devoted to the paper or its abstract, and the maximum allowed for the talk upon it. By so doing the meetings of our technical societies can be made much more attractive and the printed proceedings more valuable. It is, after all, what we know from our own practical experience or that of some one else, rather than the information gained from textbooks, that makes the safest foundation for a successful professional career, and we cannot have too much of this experience.

THE POPULATION OF THE UNITED STATES.

A recently published synopsis of the Eleventh Census of the United States shows the extent of our increase in population since 1880, and also by decades since 1790. Starting with a total population of 3,929,214 in the year last named, the decade increase is steady up to 1860, when we had a population of 31,443,321 and an increase of 8,241,445 in the preceding decade. The next decade, including the period of the Civil War, indicates a falling off in the gain of over one million, the recorded gain being 7,125,050 for the 10 years between 1860 and 1870. Between 1870 and 1880 we gained 11,597,412 in population, and in the next 10 years, up to 1890, our gain was 11,466,467, giving us a total population in that year of 62,622,250. The Superintendent of the Census explains the seeming fact that our relative gain was less in the last decade than in the one preceding it by the statement that there was an incomplete and defective enumeration in the Southern states in 1870, and that the record for that year is not to be relied upon.

In the last decade 11 states show an increase in population of over 400,000 each; and Pennsylvania and New York gained 975,123 and 914,982 respectively. Illinois comes next with 748,840, and then Texas, 643,774; Nebraska, 606,508; Minnesota, 521,052; Missouri, 510,340; Ohio, 474,250, and finally, in the order named, Michigan, Massachusetts and Kansas with gains of from 431,000 upward to the figures given for Ohio.

These figures prove that there is still much vitality in the Eastern states, so often quoted as having come to a standstill or as losing in population. Where this increase comes from is shown in the tendency to center in the larger cities, as exhibited in the fact that 10 cities indicate, in the decade, an increase of over 100,000 each in population, and of these New York and Chicago head the list. This list is as follows:

City.	Population.	Gain.
New York	1,515,301	309,002
Chicago	1,090,850	596,665
Philadelphia	1,046,964	199,794
Brooklyn	806,343	239,680
St. Louis	451,770	101,252
Baltimore	434,439	102,126
Cleveland	261,353	101,207
Buffalo	255,664	100,530
Minneapolis	164,738	117,851
Omaha	140,452	109,934

In justice to Boston, Pittsburg and Kansas City, it should be said that there has been in each case an increase entitling them to entry in the above list. But this increase is in large suburban centers not counted as parts of these cities. St. Paul, Detroit, Milwaukee and Denver also follow closely.

in the order named, with an increase in the decade of from 71,000 to 91,000. New Orleans gained less than 26,000 in this period, and San Francisco figures at only 65,000 gain, notwithstanding their commercial importance and advantages of position.

In 1880 there were 286 cities in the United States having a population of over 8,000 and aggregating a population of 11,318,547. In 1890 there were 448 cities of this class, with a total population of 18,284,385. Out of the total increase in the whole country in the decade 1880-1890, more than one-half was in the cities, showing conclusively the tendency to gravitate from the country to the centers of population. As showing how this tendency has grown, it may be said that in 1790 the per cent. of city to country population was 3.35; while in 1890 it was 29.2%. In the Southern states, however, less than 13% of the people live in cities.

The tabulated records of the Eleventh Census contain much interesting matter relating to the dwellings in the United States. The total given for the whole country is 11,483,318, with an average of 5.45 persons for each. Pennsylvania is notable as possessing nearly 1,000,000 of these, or over one-twelfth of the total, and over 100,000 more than New York. The following table shows this relation for the cities in more detail:

City.	Number of dwellings.	Number of families.	Persons to a dwelling. 1890.	1880.
New York.....	81,828	312,763	18.52	16.37
Chicago.	127,871	220,320	8.60	8.24
Philadelphia. . . .	187,052	205,135	5.60	5.79
Brooklyn.	82,282	170,970	9.80	9.11
St. Louis.....	60,937	91,756	7.41	8.15
Boston.	52,669	89,716	8.52	8.26
Baltimore.	72,112	86,654	6.02	6.54
Cincinnati.	33,487	63,530	8.87	9.11
San Francisco...	47,183	52,535	6.34	6.86
New Orleans....	43,000	48,582	5.63	5.95
Washington.	38,798	43,967	5.94	6.19

From this table we see that the average number of persons in each house has considerably increased in New York, and, to a lesser degree, in Chicago, Brooklyn, St. Louis, Boston and Baltimore. On the other hand, the average has fallen in the decade in Philadelphia, San Francisco, Cincinnati, New Orleans and Washington.

It will be unexpected information to many people to be told that in the last 40 years the foreign-born population has increased from about 1 in 25 to 1 in 7. It has increased from 2,244,602 in 1850 to 9,249,547 in 1890; and the greatest gain has been in the decade 1880-1890. In this respect, among the states, New York still keeps the lead, with 1,571,050 people of this class. Pennsylvania comes next, with 845,720, and then Illinois, Massachusetts, Michigan, Wisconsin and Minnesota. It is again the great cities that attract the foreigner coming to our shores, as they do the countrymen born on our soil; and this is reasonable, for it is at these points that they expect and do most readily find employment in the shops, factories and public works most abundant at the great centers of population.

COMMON-SENSE IN THE IMPROVEMENT OF COUNTRY ROADS.

In all the tons of literature which has been poured forth on the subject of highway improvement during the past few years, we do not recall anywhere so much sound common-sense and so few misleading generalities as we find in the report of the Massachusetts Commission on Highway Improvements. The commission have not gone into any delusive calculations as to the number of horses in the state and the cost of their keeping; nor do they pause to inquire how many of them could be dispensed with if a macadamized road led past every man's door.

In the first place, appreciating the fact that all roads cost money, and that the cost of good roads is about proportional to their excellence, they have set to work to inquire what the present highways cost and whether better ones can be afforded. The following table contains some facts which are worth examination:

Town's annual expenditure on roads.	No. of towns.	P. c. of whole No. in state.	Ave. miles per town.	Average amount spent, per mile.
$1,000 or less....	63	10.7	40.5	$16.20
$1,000 to $2,000..	85	26.6	....	28.80
$2,000 to $3,000..	57	17.8	....	38.20
$3,000 to $4,000..	28	8.7	....	.....
$4,000 to $5,000..	22	6.3	....	101.20

There are besides the above 65 cities and towns which spend over $5,000 per annum on their highways.

Evidently there are only two methods by which the highways of the state can be improved. Either by spending more money on them or by using the present expenditure to greater advantage. The commission emphatically declares that it is impossible for the 205 towns (two-thirds of the whole number in the state) which spend less than $3,000 per annum on the roads to improve their present condition. The best they can do is to struggle against further depreciation. Most of the 26 other towns which spend $3,000 to $4,000 a year on their highways are unable to improve their roads without outside assistance.

In proof of the statement that these towns, covering nearly three-fourths of the area of the state, cannot afford to spend more money on their highways, it is stated that in the poorest towns 13.7% of the taxes on the average are spent for highways, while in the wealthy cities 11.2% is the proportion which goes for highways. Really, however, the highway tax is an even heavier burden in the country compared with the city than these figures would indicate. Money is less plentiful in the country than in the city, and a larger proportion of the taxes is paid by the poor and those of small means.

It is often urged that better roads will result in a saving which will repay their increased cost; but in the case of the Massachusetts farming towns it is difficult to see where any increase in road expenditure within the bounds of reason will cause any considerable saving. The farmer cannot keep any fewer horses, for he requires those which he now has to do his farm work. The butter, eggs, poultry and other produce which he carries to the nearest town to sell cost him practically very little for haulage, and no more over a poor road than a good one. There is certainly somewhat greater wear and tear on horses, wagons and harnesses than would be the case on better roads, but the whole of the farmer's expenses in this direction are so very small that any positive saving in actual cash would be inconsiderable.

But, say the "good roads" agitators, the money which is spent on the highways is largely wasted. If it were spent to better advantage a marked improvement in the condition of the roads would result. There is some truth in this assertion undeniably, but we must make some allowance for inefficiency under any system. Is it not likely that in the work on ordinary highway repairs, the additional expense of an engineer's salary and a contractor's profit would at least approximate to the waste under the present system due to inefficient management and planning?

Really the most convincing proof that little can be done in the way of improved highways in farming towns like those in Massachusetts is the figures given above as to the expenditures on highways. Take the poorest towns with the worst roads, which spend only $16.20 per mile on the average in maintaining them, and consider that this includes all the expense of building and maintaining bridges and culverts, in a country of hills and valleys, of repairing roads after heavy freshets and of breaking roads during winter snowstorms. Evidently this leaves a very small margin for any sort of drainage or grading. Even with the roads of the next two classes, which cost $29 to $38 per mile per annum to keep in repair, very little can be done in the way of what an engineer would consider permanent improvements.

It is a favorite idea with some of the amateur enthusiasts on highway improvement that if some small part of the expenditure on roads were used in building gravel or stone roads, the improvement would be a permanent one, and, like the rope harness which was continually mended with leather until it became a leather harness, the roads of the country would in the course of years be all gravel or stone roads. It is a pity that such an easy solution of the highway problem does not exist. The defect in this plan of operation is that hard roads cost more to keep in repair than the dirt roads; and they will not, like the dirt road, gradually wear down smooth under light traffic, but must be kept in repair whether the town can afford it or not. This is one great reason why the country towns should beware of undertaking to build better roads than they can afford to build and maintain.

At the same time the golden rule in road-making is to suit the road to the traffic it has to carry. In the effort to protect the town against the expense of damage suits the road authorities are somewhat apt to put work on the little traveled roads which might more profitably be spent on the main roads carrying a somewhat heavier traffic. This is especially true of those towns which are able to spend $3,000 to $5,000 or more on their roads, as in the poorer towns even the main roads have hardly enough travel to justify making any great difference in their management.

Of course the facts which we have set forth apply only to the conditions in Massachusetts towns. It is to be remembered that in Massachusetts, and for the most part all through New England, the earth itself makes a good road for light traffic, and when it is not muddy is more agreeable to ride over than a macadamized road. But where the soil works into mud of unfathomable depth on the slightest provocation, and where large quantities of grain or other bulky products have to be carried to market, there an expenditure is justifiable which would be criminal extravagance in Massachusetts.

It is well, however, to move with caution in such matters; and this the farmers are entirely likely to do if they are not forced into extravagance by intemperate advocates of highway improvement. It is well known that the "good roads" movement has aroused little enthusiasm among the farmers, and it has been laid to their stupidity. But in view of the facts set forth by the Massachusetts Commission, it is well to consider whether the farmers have not been a good deal nearer right than some of their would-be teachers.

So long as the advocates of good roads attempted to make the farmer tax himself to build better roads than the traffic upon them warranted, their chances of success were small. Recently, however, a movement has been started to build improved roads on borrowed money secured by an issue of county or state bonds. It would be too much to say that an issue of bonds for highway improvements is never justifiable; but it is emphatically true that borrowing money for such a purpose is a risky business. A rapidly growing city or suburban town may wisely borrow money to improve its streets, and in certain cases rich farming communities on the muddy prairies might safely do the same thing. But the man or the community that borrows money to spend in a direction which will not return a good income on the investment is taking the road toward bankruptcy. The cardinal rule in investing money in the improvement of any public highway, be it a steam or electric railway, a common road or even a canal, is to make the investment proportionate to the traffic that may fairly be expected. Disregard of this rule has put many a steam railway which ought to have paid good dividends into a receiver's hands, and from present appearances many projectors of electric railways seem likely to make a similar mistake. It is to be hoped that the country may commit no widespread folly of this sort in the management of its common roads.

One other point of the Commission's report which deserves mention, is its reference to the use of broad tires. The commission thinks any legislation or other action on this subject would be unadvisable, holding that experience has taught the builders and users of wagons more than theory would be apt to. Recent experiments have shown that only on a soft and yielding surface is resistance to traction reduced by the use of broad tires. To attain the minimum traction resistance the tire should be just broad enough not to sink into the road; any increase in width beyond this rapidly increases the resistance.

As a whole the report of the Commission reflects much credit upon its members, and we are exceedingly glad to record the fact that two of the three members are engineers, the board being made up of Messrs. Geo. A. Perkins, Wm. E. McClintock, M. Am. Soc. C. E., and Prof. N. S. Shaler, Dean of the Lawrence Scientific School.

Immigrants are to be expected in swarms within the next few weeks at our ports. According to reports from abroad, 10,000 Italians have left Marseilles on the eleven steamers that sailed from that port previous to May 3, and 13,000 are said to be on the road from Bremen, with large migrations reported from other sailing points. This exodus to the United States is due to the new law affecting steerage passengers, who leave foreign ports after May 3, subjecting them to a new system of questions at Ellis Island and the new Board of Inspectors.

LETTERS TO THE EDITOR.

ECONOMY IN WOODEN AND METAL RAILWAY TIES.

Sir: To start with, let me say what most practical and scientific men well know, that railway corporations are too conservative for their own good, or the good of the public. This proposition could be illustrated in many ways. Cheap transportation is undoubtedly desired, and at once; but we must not overlook the question of remunerative profit to the parties who supply the money to accomplish this result. How can both these ends be attained? The reply is, by saving time—which is money. To save time, quicker speed must be made. This means improved facilities, such as machinery, roadbed, etc. It is not proposed here to consider the former, but to speak of the latter. It will be generally admitted that wooden ties, regardless of the character of the ballast used, are the cheapest as to first cost, and the most expensive in the end. Iron ties are most expensive as regards first cost, but cheapest in the end, estimating for a period of ten years. So that corporations cannot plead expense as a reason for not using iron ties, unless they think that a temporizing policy is best.

In saying this, the particular form of iron tie is not considered; I am speaking of iron ties in general. It is well known that good, substantial iron ties are now obtainable at about three times the cost of good wooden ties. As to safety and solidity of roadbed made with iron ties, there can be no question that it is far superior to that made with wooden ties. It is too well known by railway constructors to need verification, that the use of wooden ties necessitates the employment of spikes to hold the rails down, and that rails held by spikes do not remain in line, even with the most careful watching and driving. On curves, especially, it is a very unsafe method, because with the heavy trains now in use, the spikes loosen and the rails spread. It is, in fact, a crude and dangerous method to use at even a moderate speed of train, and absolutely inexcusable where faster speed is used. The time has now arrived when the public will no longer tolerate such stupidity. They will not any longer call it conservatism or bad judgment, but criminal carelessness.

With iron ties of any known form, the rails are securely held in line and firmly clamped to the ties, and no influence, whether that of speed of train or any other, can separate rail from tie. As far as these considerations go, no accident can occur to the train from spreading rails. The roadbed is absolutely safe under all conditions of train service. These facts being so, it is a great wonder that the traveling public do not rise up and demand of corporations that they abandon their penny-wise and pound-foolish plan, and adopt the policy dictated by common sense and experience.

The trouble does not lie with the railway superintendents, but with the railway directors who hold the money bags, and think more of speculating in the fluctuations of stocks than in affording safe conduct for man and beast. J. M. H.

New York, N. Y.

(Our correspondent is going ahead rather too fast in his sweeping demand for the introduction of metal ties, and we do not think their introduction likely to be promoted very rapidly by a demand from the traveling public, which would be offset by a vigorous protest from stockholders. Such improvements are not introduced suddenly, but by a gradual growth and development, and in many cases there are other improvements which might well be made before the cost of metal ties is incurred. We fully recognize the advantages to be derived from the use of a well designed metal track, and expect to see such track become more and more general, especially on main lines with exceptionally heavy traffic, in which case the economy in maintenance and renewals and in the stability of track outweigh the extra first cost. A very significant case of this kind is on the four-track line between the Grand Central station, in New York, and Mott Haven, where the New York Central & Hudson River R. R. will lay 100-lb. rails and steel ties, as already noted in our columns. There are some important points, both technical and financial, which are overlooked in the above letter. While there are many cases on the busy lines of the rich companies, where metal ties might well be introduced, there are many railways which could not afford the great increase in first cost, even for busy sections of line. But it does not therefore follow that the tracks of the latter railways will necessarily be unfit for high speed. With such improvements as preserved ties, steel tie plates, improved fastenings and other appliances, and a general better maintenance of track, a track can be made which will be perfectly safe under high speeds and heavy traffic, and which will be really more economical than the metal track, particularly if we compare the two for a period of ten years only, and remember at the same time that the cost of metal ties and reconstruction of track would be almost prohibitory in many cases. Our correspondent refers to "iron" ties, but we take it for granted that he refers to steel as far as this country is concerned.

Granting that spikes are inefficient fastenings under heavy and high speed traffic, it will be cheaper, and in general more economical, to use improved fastenings and adopt a higher standard of track maintenance, than to reconstruct the track with metal ties. When such improvements as noted above have been made to track with wooden ties, special care should be taken to maintain the track in standard condition. Railway companies are certainly prone to be rather too conservative in their track work, but they are not philanthropic corporations and naturally wish to get along without very extensive expenditures, and it must be admitted that as a rule the real economy of large expenditures on improvements are not sufficiently recognized. On the other hand, of the numerous forms of metal ties which have been tried in service a comparatively small number has proved successful, and these are continually being improved upon. It is quite an unsustainable statement that "with iron ties of any known form, the rails are securely held in line and firmly clamped to the ties." The Pennsylvania R. R. has had unsatisfactory results from its ties from their being inefficient, as pointed out in our issue of July 28, 1892, and similar results have been obtained with other forms of ties. A poor and inefficient metal track is more expensive both in first cost and maintenance than a good track on wooden ties, and may be less safe under traffic. With regard to the fastenings of rails to metal ties, an endless variety of arrangements of bolts, clamps, rivets and keys have been devised and tried, but only a few of them have proved satisfactory in service. Many of them are very complicated and therefore objectionable at once; others allow the rails to get loose and rattle, and in some cases spreading has occurred. On the other hand, there are sometimes indiscriminating statements made that metal track commonly has proved a failure (Eng. News, July 28, 1892), which is very far from being the truth. What is wanted in metal track is a strong steel tie of ample weight and thickness, easy to manufacture and tamp, and of reasonable cost. With this must be fastenings that are simple and efficient, consisting of as few parts as possible. Such a track well laid and ballasted, and well looked after, will require little work for maintenance and few renewals, effecting economy therefore in its durability and in the reduction of track work, which it is so difficult to get properly done on lines with heavy traffic. This is the kind of track which we hope to see introduced more and more rapidly. But what is wanted even more than this, particularly on lines with fast traffic, is a thorough improvement of existing track, with careful maintenance. To improve existing tracks in this way, and then steadily proceed with the introduction of metal track as financial and traffic conditions warrant, will be the best and most satisfactory practice and will be equally to the benefit of the railway companies, the stockholders and the traveling public in point of safety, economy and convenience. As to the traveling public getting up and demanding metal ties, that would be a very foolish thing for the public to do, and, even assuming that its demand was heeded, harm rather than good would be the result to all concerned. Railways are improved by steady development and not by sudden ill considered revolutions.—Ed.)

FINDING THE ARC OF A CIRCULAR SEGMENT.

Sir: In your issue of April 27, I notice a communication from Mr. T. P. Perkins, giving an exceedingly simple formula for finding the area of a circular segment.

I think, however, that your correspondent has made a slight error in defining the meaning of "arc," which should be the actual length of arc, or "length of arc to radius one," multiplied by the radius.

A more convenient form for expressing this formula would be area of circular segment $= \frac{R^2}{2}$ (arc $-$ sine A) in which R=Radius of arc, arc=length of arc to radius one, sine A=natural sine of central angle to radius one. As can be readily seen, the formula is really a simple expression for difference between the "large areas" mentioned by your correspondent.

Yours truly, A. S. Tuttle.

Brooklyn, N. Y., May 4, 1893.

NOTES AND QUERIES.

J. J. Shannon & Co., Philadelphia, Pa., ask for whom the Andrews oscilliating engines are made, or where they can be obtained.

VARIATION OF THE COEFFICIENT OF FRICTION WITH DIFFERENT LOADS AND BEARING METALS.

By Joseph Kuhn, Lima., O., and Robert T. Mickle, Millville, N. J., graduates in the class of 1892, Sibley College, Cornell University.

Graduating Thesis awarded Third Prize in Engineering News Competition, of 1892.

Preface.—The wide range of the coefficient of friction of the different alloys of copper, tin, lead and phosphorus, and the lack of experiments, have led to this work. After carefully reviewing the field and profiting by the experience of others, a machine was constructed which, though essentially like some of those already constructed, has some improvements and changes, to meet the special work for which it was designed. The improvements are: The avoidance of all calibrations, and the ease of changing and fitting test bearings.

Credit should be given for the fore part of this work to the various articles on the subject by Messrs. Thurston, Tower, Woodbury, Denton and others. A list of references to these authorities is given below.*

Part I. Abstract of Work of Previous Investigators.—As far as the literature of the subject goes, no work was done in determining the friction of two substances, one rubbing upon the other, prior to that of Coulomb. That was in 1781. Gen. A. Morin, in his "Mechanics," says that Coulomb "agrees" with him in the following "laws"—the results deduced from his experiments, which were made in 1830:

Friction is: 1. Proportional to pressure. 2. Independent of the extent of the surface of contact. 3. Independent of the velocity of motion, with some restrictions, which subsequent experiments did not confirm.

The first law practically says that the coefficient of friction is constant. This has not been confirmed by the results of later experiments. This will be referred to later on. The second law is to a certain extent contradicted in the case of well lubricated surfaces, for in those cases the friction is more that of liquids than that of solids, and it is well known that the friction of liquids varies "directly as the amount of rubbing surface" (see Church's "Mechanics," p. 675). As regards the third law, this is also contradicted by the results of experiments carried out at various times during the last 50 years. Morin himself does not consider it a law, although stated as such in his "Mechanics," for, after stating it, he says: "The friction is constant and independent of velocity within the limits of the experiments," and these are known to be within a narrow range. This will also be referred to later on.

Morin's "laws" have been very generally accepted to be correct, and widely copied in textbooks relating to the subjects; this is so, notwithstanding the fact that many experiments have been made before the textbooks were printed.

Following Morin, little was done in 1852, when Poiree and Bochot experimented on the friction of brake shoes, and concluded as the result of their experiments that the coefficient of friction diminished considerably as the velocity increased. It will be noticed that this is contradictory to Morin's third law.

From 1877 on, a large amount of work has been done, so much as to make it difficult to determine the

*References: W. R. Brown, "Engineer" (London), Vol. LVIII; J. E. Denton, "Trans. Am. Soc. Mech. Eng.," Vol. XII.; C. B. Dudley, "Jour. Franklin Inst." Vol. CXXXIII.; Galton and Westinghouse, "Van Nostrand's Magazine," Vol. XIX.; J. Goodman, "Inst. C. E. (English) Proceedings," Vol. LXXXV.; A. B. W. Kennedy, "Engineer" (London), 1884; A. S. Kimball, "Van Nostrand's Magazine," 1887; Snowden, "Engineer" (London), 1884; R. H. Thurston's "Friction and Lost Work"; B. Tower, "Inst. Mech. Eng." (Birmingham), 1883, 1884; A. M. Wellington, "Trans. Am. Soc. C. E.," Vol. XIII.; C. J. H. Woodbury, "Trans. Am. Soc. Mech. Eng.," Vols. I.-VI.

order in which it was completed. In that year Professor Kimball made experiments on the variation of friction with velocity of a wrought-iron shaft, running in a cast-iron box, and concluded that as the velocity increased from 6 to 100 ft. per minute the coefficient decreased considerably, and then increased.

About this time Dr. Thurston made a large number of experiments upon a machine designed especially for that purpose, shown in Fig. 1 and described as follows:

At F is the journal on which the lubricating material is to be placed for test. This journal is carried on the overhung extremity of shaft A, which is sustained by the journals B B' on a standard D, mounted on a base plate E. The shaft is driven by a pulley C at any desired speed. A counter is placed at the rear end of this shaft to indicate the number of revolutions. The shaft is usually driven at a fixed speed, corresponding to a velocity of rubbing surfaces approximately that of the journals on which it is proposed to use the oil. The testing journal F is grasped by bearings of bronze G G', and with a pressure which is adjusted by the compression of a helical spring J. This spring is carefully set, and the total pressure on the journal and the pressure per square inch are both shown on the index-plate N, by a pointer M. Above the journal is a thermometer Q, of which the bulb enters a cavity in the top "brass," and which indicates the rise in temperature as the test progresses.

The "brasses," thermometer and spring are carried in a pendulum H, to which the ball I is fitted; and the weights are nicely adjusted, and as nearly as may be in such a manner that the maximum friction of a dry but smooth bearing shall just swing it out into the horizontal line. The stem K K', of the screw, which compresses the spring, projects from the lower end of the pendulum, and can be turned by a wrench. A pointer O traverses an arc PP', and indicates the angle assumed by the pendulum at any moment. This arc is carefully laid off in such divisions that dividing the reading by the pressure shown on the index N gives the corresponding coefficient of friction.

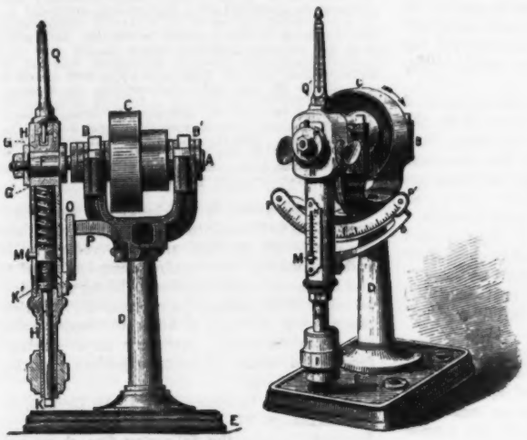


FIG. 1. THURSTON'S TESTING MACHINE FOR LUBRICANTS.

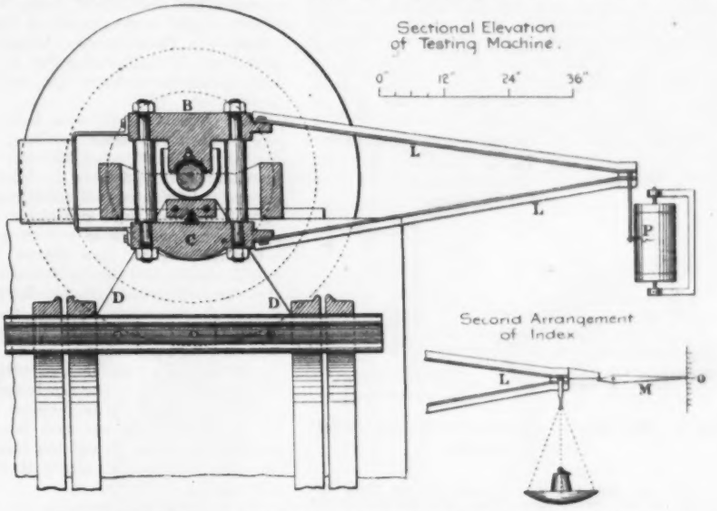


FIG. 2. TOWER'S MACHINE FOR EXPERIMENTS ON JOURNAL FRICTION.

From the results of his experiments, Dr. Thurston comes to the conclusion that up to a certain speed the coefficient decreases, and then increases as that speed is passed. This speed varies with the temperature and pressure.

Galton and Westinghouse, in 1878, found that the friction on brake shoes decreased with an increase of speed from 400 to 5,300 ft. per minute. Although their experiments were very extended, some doubts have been expressed regarding the results because they were not able to make determinations lasting more than half a minute.

In 1883, B. Tower made a set of experiments, the results of which he read before the Institution of Mechanical Engineers (Birmingham). His machine is shown in Fig. 2, and decribed as follows:

The journal experimented on was of steel, 4 ins. in diameter and 3 ins. long, with its axis horizontal. A gun-metal brass A, embracing somewhat less than half the circumference of the journal, rested on its upper side. The exact arc of contact of this brass was varied in the different experiments. Resting in this brass was a cast iron cap B, from which was hung by two bolts a cast-iron cross bar C, carrying a knife-edge. On this knife-edge was suspended the cradle D, which carried the weight applied to the bearing. The cap, bolts and cross-bar were put together in such manner as to form a rigid frame, connecting the brass with the knife-edge. If there had been no friction between the brass and the knife-edge, the weight would have caused the knife-edge to hang perpendicularly below the axis of the journal. Friction, however, caused the journal to tend to carry the brass and the frame to which it was attached round with it, until the line through the center of the journal and the knife-edge made such an angle with the perpendicular that the weight multiplied by the distance from the knife-edge to that perpendicular offered an opposing moment just equal to the moment of friction.

In order to avoid the difficulty of determining accurately when the knife-edge was perpendicularly under the center of the journal, each experiment was tried with the journal revolving in both directions, and the sum of the value of s (s = distance from the knife-edge to the above mentioned perpendicular) on both sides was measured, and then the coefficient of friction was indicated by the chord of the whole angle included between the two lines of inclination caused by the friction with the rotation in two directions, the chord being expressed in terms of the diameter of the journal. Each result was thus a mean of two experiments, one with the axle running in one direction and the other with it running in the other direction. In order to read the value of the coefficient thus obtained, a light horizontal lever was attached to the frame connecting the brass to the knife-edge. The position of the end of the lever during each experiment was recorded by a tracing point attached to the end of the lever and marking on metallic paper carried on a revolving vertical cylinder. The distance between two lines obtained by running the axle both ways indicated the value of the coefficient.

Tower used a great variety of speeds and pressures. Regarding the friction, he says:

The friction depends on the quantity and uniformity of distribution of the oil, and may be anything between the oil bath results and seizing, according to the perfection or imperfection of the lubrication. The lubrication may be very small, giving a coefficient of friction of 1-100, but it appears as though it could not be diminished and the friction increased much beyond this point without risk of seizing.

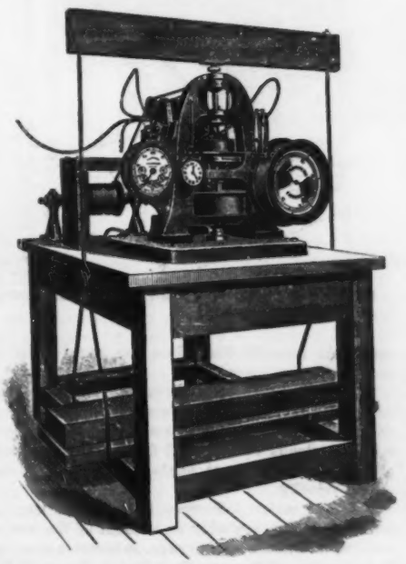


Fig. 3. Woodbury's Machine for Experimenting on Friction Between Rotating Disks.

Mr. C. J. H. Woodbury made two sets of experiments, one on the value of lubricants, and the other on the friction of journals at various pressures and temperatures. The machine is shown in Fig. 3, and is described as follows:

The operation of the machine is based on the friction between two annular disks, and the whole is designed for observing this with precision. The machine consists of a cast-iron frame in the form of an arch with a brace at the rear, and further stiffened with transverse webs to present the utmost rigidity against the stresses liable to be applied to the machine.

The lower disk is secured to the top of an upright shaft, its top being an annulus ground to a true plane surface. Upon this rests the upper disk, which is in the form of a hollow ring based upon a flat plate, and is made of very hard composition cast in one piece. The bottom of this disk is scraped to a true plane surface, so that the contact between these two disks is uniform. A partition (Fig. 3) divides the interior of the hollow ring forming the upper disk, so that water can be introduced to the connecting tubes to control the temperature of the disks, and in some instances it is desired to use the water as a medium to retain the heat of friction. The sides and top of the upper disk are surrounded by a case made of hard rubber, and the space is filled with eider down.

A tube of thin copper, closed at the bottom, reaches through the bottom of the disk, and a thermometer with its bulk placed within this tube indicates the temperature of the frictional surface. A tube leading through the upper disk conducts the lubricant under trial to the recess in the lower disk. The upper end of this tube, being of glass, indicates the supply and rate of feeding of oil.

Over the upper disk a yoke with four arms rests upon four columns which extend through the upper disk to the middle of the frictional surfaces, these columns being cast as a portion of the disk. In the center of this yoke is a hole with a hemispherical bottom. The lower end of the upper spindle is round, and fitting into this hole makes a ball and socket joint. This construction transmits the stress due to the weight applied upon the spindle to four points in the middle line of the frictional surface and the strain due to excessive loads will not distort the disks so as to interfere with the uniformity of the thickness of the film of oil between the surfaces, while the ball and socket joint allows the surfaces to meet without any cramp or binding due to imperfection or wear which would prevent the surfaces from revolving in a true plane. The axes of the upper and lower spindle do not coincide, but are on parallel lines about ½ in. from each other. This prevents the surfaces from wearing in rings, because the same points are not continuously brought into contact with each other.

A slight countersink in the top of the upper spindle receives the center point in the middle of a beam which sustains the weighted platform beneath the table. The weight pressing the disk together is thus exerted along the axis of the upper spindle.

Instead of holding this spindle in ordinary journals, the friction of motion was substituted for the friction of repose by placing two pulleys whose arbors were long sleeves at the two points of support and running the spindle through the middle of these pulleys. The torsional effect due to friction of the pulleys against the spindle was nullified by revolving them in reverse directions, so that the friction of motion due to 1,000 revs. per minute was substituted for the greater friction of repose.

At the left of the machine, a counter records the number of revolutions made during any given time.

The dynamometer shown on the right of the machine consists of a mechanism of segments and pinions for multiplying the deflection of a steel bar and indicating the stress necessary to produce such deflection by the position of the hand on the dial. An arm which ends in the arc of a circle projects from the lower surface of the upper disk, and is connected to the dynamometer with a flexible brass tape. When the machine is in operation the lower disk is revolved and tends to carry the upper disk around with it by a force equal to the friction due to the lubricant between the disks.

In his experiments, Mr. Woodbury used a variety of light pressures, and thorough lubrication. They seem to indicate that the coefficient is inversely as the pressure.

Mr. A. M. Wellington made a set of experiments upon the friction of journals at slow speeds and

heavy pressures, and from his report the following is quoted:

The apparatus is shown in sufficient clearness in Fig. 4. The axle A to be tested is placed in an ordinary lathe, having as great a variety of speeds as possible. The testing apparatus as actually constructed consists of an oak beam C, carrying the compound lever L L'. The yoke E encircles the axle, and bears against the brass B underneath it, thus furnishing the necessary resistance to the action of the levers, and throwing the same load upon the lower brass B as is imposed by the levers directly on the upper brass by transmission through the pin B, the latter being passed through a hole in the beam C. The pressure was transmitted to both the upper end and the lower brass by suitable iron blocks (shown in the cut directly above and below the brasses), representing as nearly as might be the ordinary form of the top of a journal box.

As thus constructed, it will be seen that the entire apparatus (when properly balanced, which is perfected by the light counter-poise H) is poised in unstable equilibrium on the axle A, and opposes no resistances to motion in either direction, except such as arise from friction. A very heavy load may be thrown on the bearings, viz., 6,000 lbs. (3,000 lbs. on each bearing) for every 24 lbs. of load W, placed on the extremity of the compound lever; but the only weight thrown upon the lathe centers is the dead weight of the apparatus itself, which was kept constant at 205 lbs.

The load thrown upon the bearings by this apparatus consists (1) of the entire dead weight of the apparatus, including both brasses, the weights W, and all the intermediate parts which rest entirely upon the upper

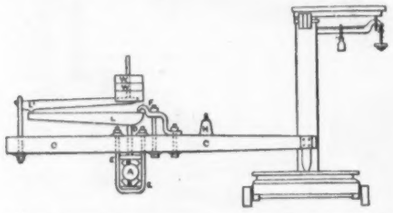


Fig. 4. Wellington's Apparatus for Testing Journal Friction in a Lathe.

brass B; (2) the load thrown upon the pin D by the weight of the levers themselves and (3) the strain produced on the levers by the addition of the weights W.

When the axle A is caused to revolve the lever C is held stationary by the platform scale, and it is obvious that the pressure produced upon the scale furnishes an exact and direct measure of the journal friction.

Goodman and Stroudley give as "laws of friction" of well lubricated substances (based upon the results of Tower, Stroudley, Wellington and Kimball) the following:

(1) The coefficient of friction with the surfaces efficiently lubricated is from 1-6 to 1-8 that for dry or scantily lubricated surfaces.

(2) The coefficient of friction for moderate pressures and speeds varies approximately inversely as the normal pressure; the frictional resistance, as the area of contact, the normal pressure remaining constant.

(3) At very low journal speeds the coefficient is abnormally high, but as the speed of sliding increases from about 10 to 100 ft. per minute the friction diminishes and again rises when that speed (100 ft. per minute) is exceeded, varying approximately as the square root of the speed.

(4) The coefficient of friction varies approximately inversely as the temperature within certain limits, namely, just before abrasion takes place.

The latest experiments upon this subject are those of Prof. J. E. Denton, a report of which he read before the American Society of Mechanical Engineers (Vol. 12) the following description and cut are taken from this article:

An ordinary railroad car axle D (Fig. 5) has forced upon it a 12-in. wheel A, as is the ordinary car wheel. The wheel A supports one end of the axle on the friction rollers B, 3¾ ins. in diameter. The other end of the axle is carried in an ordinary bearing on brick work and can be coupled positively to the main shaft of a 25-HP. steam engine C. The axle can also be driven by a belt in the direction opposite to that of the engine, for the purpose of calibration, to be explained below. The test journal is at E. It is pressed upon by the brass, which may be of special form or it may be like the ordinary Master Car Builder brass. This is drawn toward the journal by a jackscrew K, connected by the linkage shown in dotted lines to the steelyard M which is anchored to the beam N, lodged in the brickwork O. The screw K has for its nut the crosshead H, having knife-edges J, from which the links G extend upward to connect with the yokes in which the block F is confined. The steelyard has its counter-poise weights S to S suspended upon two rods S S, so that when these are lowered by a screw in the hand-wheel S the weights come upon the hand-wheel in succession. A reciprocating motion is given to the brass by the worm wheel ℅, which moves the slide, a, back and forth at one-fifth the rate at which the test journal revolves. The movement of a can be varied by an eccentric cam from nothing to ⅛ in. in each direction. A fan draws air from the atmosphere outside the building, which is available to create a breeze against the test journal having a velocity of about 30 miles per hour. The friction is weighed upon the double beam h. In order exactly to subdivide the load on the journal so that precisely equal amounts will act through each of the links G, the knife-edges J are provided with lugs I fastened with a set screw in a slot as shown. By means of these the knife-edges can be slightly rotated, nearer to or farther from the center line of the test axle and thereby adjust the relative strain in the two links G. It is impossible to construct the machine work so that the knife-edges J will be so accurately located, by measurement, as to equalize the strain in the links G. Hence all that can be accomplished with lugs I is to adjust them when the lubrication is perfect and the pressures light so that opposite directions of running give equal amounts of friction and then determine the friction for greater loads by making it equal to half the sum of the friction shown by running in opposite directions. To eliminate the pad friction, the pan b, which contains the latter, together with the oil to be tested, is supported free from the frame work around the block F by a support c. The rods p support a bar which carries a counterweight O, by means of which the sensitiveness of the friction lever h is controlled.

The above is a general outline of the machines, and work which has been done upon them up to the present time.

Morin first formulated laws, which have been widely copied and applied to friction under all conditions. These laws are known to be incorrect, and Morin himself states that he formulated the laws for those conditions only under which he experimented.

More recent experiments, both with lubricated and with unlubricated surfaces, show that the laws are different under different conditions. It is becoming more and more the belief that the laws governing lubricated and unlubricated surfaces are entirely different, and that the laws for lubricated surfaces approach those governing fluid friction.

Experiments on shoe brakes by Galton and Westinghouse, and also by Poiree and Bochet, show that the coefficient of friction decreased as velocity increased, the range being in the first case 400 ft. to 5,300 ft. per minute. In the latter case 900 ft. to 3,600 ft. per minute.

With lubricated surfaces, experiments by Professor Thurston lead to the conclusion that the coefficient decreases with an increase of speed up to 100 ft. per minute, and then increases again for greater velocities. Tower has come to the conclusion that the critical velocity is about 150 ft. per minute.

Goodman, in experimenting on journal friction, places this critical velocity at 100 ft. per minute, where the friction remains constant for a considerable space. This for loads of 400 lbs. He also makes the statement that the friction increases

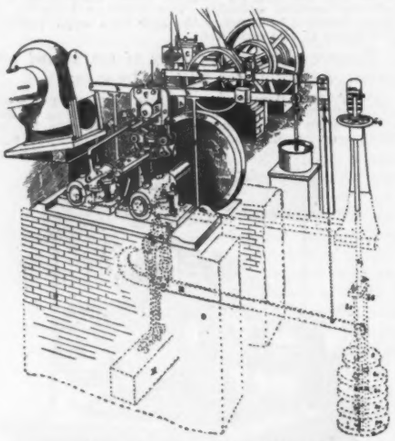


Fig. 5. Denton's Lubricant Tester for Heavy Pressures.

for loads over 60 lbs. when the speed falls below 50 ft. per minute.

Results from these experiments on well lubricated journals lead to the conclusion that the coefficient of friction decreases as the speed increases up to a velocity of from 100 ft. to 150 ft. per minute, when it increases again as the square root of the velocity.

A factor which influences friction and was not noted by Morin, probably on account of the low velocities, and hence small range, is temperature. As it increases, within practical limits, the coefficient of friction decreases.

Contrary to Morin's first law, numerous experiments show that the frictional resistance with moderate loads and velocities is practically constant. That is, if the load is doubled, the coefficient of friction is halved.

With regard to very low velocities, Wellington reaches the following conclusions:

1. Friction at very low journal speeds of 0+is abnormally great, and more nearly constant than any other element of friction. Under varying conditions of lubrication, load and temperature, it varies from 18 lbs. to 24 lbs. per ton (coefficient 0.09 to 0.12) for loads of from 30 lbs. to 280 lbs. per sq. in. Within these limits it is not greatly modified by change of temperature.

2. This abnormal increase of friction is due solely to the velocity of revolution, continuing unchanged so long as the velocity is unchanged, and returning to the same amount whenever the velocity is reduced to the same rate, barring exceptional slight variations probably due to differences of lubrication and temperature. It is not appreciably affected by the fact that the journal may be just starting into motion, or is just coming to rest, or is temporarily reduced to a velocity of zero during continuous motion.

3. At velocities higher than 0+, but still very slow, the same general law obtains. The coefficient falls very slowly and regularly as velocity is increased, but is constantly more and more affected by differences of lubrication, load and temperature.

4. A very slight excess of initial friction proper (varying from ¼ to 2 lbs.) could generally (but not always) be observed over that which continued to exist at the nearest approach to a strictly infinitesimal velocity which it was possible to obtain. This difference was by analogy ascribed solely to the fact that the lowest continuous velocity attainable was not strictly infinitesimal, and the final conclusion was drawn that,

5. There is no such phenomenon in journal friction as a friction of rest, or a friction of quiescence, in distinction from (i. e., differing in amount from friction of motion at slow velocities and due to the fact of quiescence. The fact that friction of rest, as such, appears to exist, is due solely to the fact that no journal or other solid body can be instantly set in rapid motion by any force however great.

From the above it will be easily seen that it is impossible to formulate any fixed and rigid laws for the coefficient of friction. Temperature, velocities and methods of lubrication, composition of bodies and character of the surfaces sliding on each other, all enter in to change the coefficient of friction. In other words we have to know the exact conditions, and then formulate laws for each specific case from data obtained from experiment under the same conditions.

In regard to bearing alloys, C. B. Dudley, in Vol. CXXXIII., p. 81 of "The Journal of the Franklin Institute," gives the following five characteristics of a good bearing metal, as demonstrated by numerous experiments made on car truck bearings in actual use.*

1. "The bearing must hold up the load." In speaking of babbitted bearings as compared with a solid metal bearing he does not think that the superiority of the former over the latter is sufficient to warrant the trouble of making babbitted bearings.

2. That the bearing does not heat readily. The general tendency of all the information which is at hand on this subject is that the harder the bearing metal, the more readily it will heat, or to put it in another form, the softer the alloy, the less liability there is for the bearing to heat.

3. That the alloy should work well in the foundry. Castings made from metal which has been exposed to the air and so partially oxidized are always more or less spongy and inferior. Two things tend to correct this: (a) The addition of from 1℅ to 2℅ of zinc. (b) The addition of a small amount of phosphorus, either as phosphor tin or any of the phosphorized alloys found in the market.

4. A good bearing metal should show small friction. On this point it may be urged that the friction is wholly a question of the lubricant used and all the experiments seem to confirm this view, to a greater or less extent, namely, that the largest portion of the friction between a bearing and its journal is a function of the lubricant used. On the other hand, the nature of the bearing metal does certainly have an influence, and a good bearing is one which makes the element of friction depending on the metal as small as possible. Experiments on this subject are few and hard to make on account of variables, notably, temperatures, quantity of oil between surfaces, pressures, speeds, relative smoothness of surfaces, etc.

5. It is extremely important that a journal should give high mileage with small loss of metal by wear. The Pennsylvania R. R. make their tests by comparing the metal to be tested with a standard metal, which is a phosphor bronze—made by the Phosphor Bronze Smelting Co.—and called S bearing metal. It contains about 79.70℅ of copper, 10℅ of tin, 9.5℅ of lead and about 8℅ of phosphorus. A phosphor bronze bearing is put at one end of an axle and the bearing to be tested at the other end. In a four-wheel truck the standard bearings are placed diagonally opposite, so that a standard and test bearing are on the same side of truck, thus making the conditions as near the same as possible for all bearings. These tests were for wear only. With a copper-tin alloy to which lead was added it appears from the results of these experiments that better results are obtained as the proportion of lead is increased. Metals which are to give the least loss of substance by wear independent of what the load, speed, temperature, etc., are, should have these requirements: (1) That material which will suffer the most distortion without rupture will wear best. (2) The first variable being obtained in satisfactory amount, an increase in tensile strength will add to the wearing power of the metal. (3) "Granular structure." That is of two metals having the same elongation and tensile strength, that with the finer granular structure will have the best wearing qualities.

The subject of lubrication is so intimately connected with that of journals and bearings that it seems best to take it up next. Free lubrication requires that the lubricant should keep the surface apart, and the globules form rollers or vehicles for the surfaces to be carried upon that are to be lubricated.

The qualifications of a good lubricant, as laid

*See also Eng. News, March 26, 1892.—Ed.

down by W. H. Bailey, in Vol. 45, p. 372, Proc. Inst. C. E., are:

(1) Sufficient body to keep the surfaces free from contact under maximum pressure. (2) The greatest possible fluidity consistent with the foregoing condition. (3) The lowest possible coefficient of friction, which in bath lubrication would be for fluid friction approximately. (4) The greatest capacity for storing and carrying away heat. (5) A high temperature of decomposition. (6) Power to resist oxidation or the action of the atmosphere. (7) Freedom from corrosive action on the metals upon which used.

The degree of lubrication is effected largely by the method of applying the lubricant. Tower's experiments, made under different methods of lubricating, show that a bath lubrication is the most efficient. Bath lubrication is defined as the amount of oil capable of adhering to the journal when touching the oil, and being carried between the bearing and journal, or the oil may be applied to the journal by a pad saturated with it. The point of application of the lubricant should be at the point of no pressure on the journal, as experiment shows that a pressure greater than 200 lbs. per square inch on the bearing would not allow the oil to flow down on the journal when applied through an oil hole in the bearing, whereas, with the oil applied on the journal, at the point where no pressure comes upon it, the oil would be carried between journal and bearing by capillary attraction and adhesion when the load on the bearing was as great as 625 lbs. per square inch.

The following theory by Mr. Snowden (see "London Engineer," March 28, 1884) probably explains the action of the oil between the bearings and journal when applied by bath lubrication. The friction of liquids in pipes increases as the pipes grow smaller, and must be very great in capillary tubes, and must also be greatly affected by small variations in the size of the tubes. Just so in a journal.

As soon as a new journal has run awhile its surface becomes smoothly polished by the grinding action of the prominent portions of the surfaces against each other. The wear of the shaft and step both contribute to minimize the pressure at the edges and cause it to be greatly concentrated toward the crown of the bearing where the load comes. Imagine now what takes place; the oil in the oil bath touches the journal, which is wetted by it as it revolves; and on reaching the edge of the box where the pressure is small all except a thin film may be scraped off. This film, which is partly in absolute contact with the surface, is carried forward almost as if a part of it, and after a turn or so a layer of liquid is carried by the friction,—which as I have previously stated becomes very great in capillary channels,—between the boxes and the journal. This film supports the whole of the load, and so long as the rotation continues is maintained so as to keep the surfaces separated, for if its thickness decreases, the friction increases and the moving surface brings round with greater force its film, so it adjusts its thickness according to the load, the speed and the supply of the lubricant.

From the above results we may define a proper method of lubrication to be one in which the lubricant is applied to that part of the journal where there is no pressure by a bath, a pad, or a roller in the oil. Of the various machines described, nearly all have their disadvantages as well as advantages. For instance, Tower's required the handling of a great number of heavy weights. Thurston's machine has a very heavy spring, which, although handy in getting direct readings requires calibrations and, consequently, corrections. This necessitates removing some of the parts. Woodbury's machine is also very handy and well constructed, but is suitable for light pressures only. His dynamometer spring also requires calibration. Wellington's machine is cheap, easily constructed and convenient, but in order to change from one bearing to another the entire machine must be lifted or blocked up, which makes it unhandy. For heavy work, Denton's is all that could be desired, except as regards expense.

(To be continued.)

AN ELECTRIC PUMP FOR SHAFT SINKING.

Every contractor who has ever undertaken to sink a deep shaft through water-bearing material will be interested to learn that an electric pump especially designed for shaft sinking has been put on the market by the General Electric Co. The great disadvantage of the steam pump is that the pump must be stopped to put in new lengths of steam, exhaust and discharge piping, as the shaft is lowered. With very wet shafts the water is apt to rise before this work can be completed and the pump is started again. In deep shafts very heavy steam pressures are required, and the hurriedly made joints are apt to blow out, causing further delays. We need not enlarge, however, on the difficulties experienced in sinking deep shafts through wet material, for every contractor who has done such work knows them only too well.

With the electric pump all these difficulties with the piping connections are done away with. The insulated wire which conveys the electric current to the pump may be wound on a reel, and no new connections need be made from the time the shaft is begun until it is completed. The discharge pipe may, if desired, be lengthened at the top as the shaft is lowered and this can be done so conveniently and quickly that the pump need be stopped only a very short time. Besides these enormous advantages, there is no nuisance of leaking steam, of unbearable heat in the shaft, of men burned against hot steam pipes; and the heavy loss by condensation in sending steam down a deep shaft in a bare pipe is avoided.

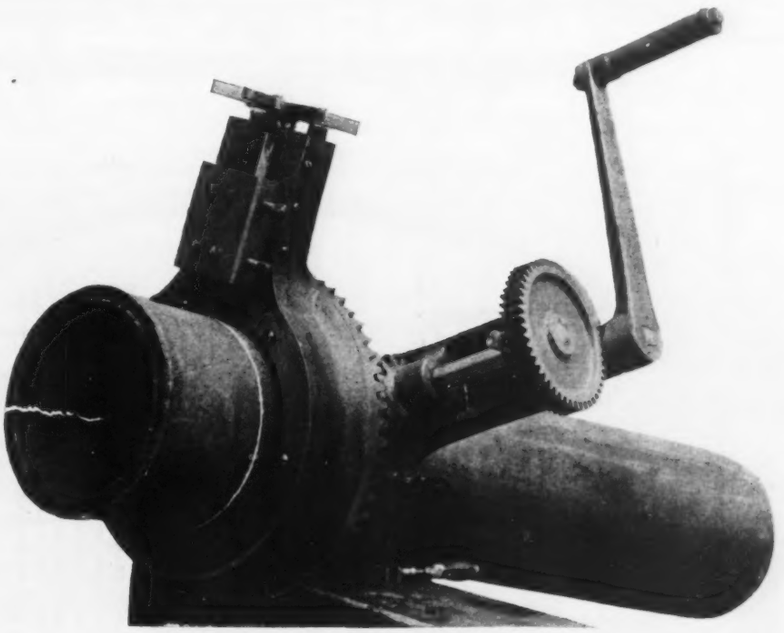
The complete machine consists of a duplex double-acting pump with outside packed plungers, driven by an electric motor. The motor with its gearing and operating mechanism is inclosed in a cast steel casing absolutely watertight. In fact the only moving parts visible about the machine are short sections of the plunger rods. Thus the pump will work as well under water as out of it—in fact, rather better, the cooling action of the water increasing the efficiency of the electric motor. If, therefore, the precaution is taken to use thoroughly insulated cables for conveying the electric current to the pump, it may be "drowned" by a sudden rush of water in the shaft, and will continue steadily at work. Even should the case leak slightly, the motor in the upper part of the case, within a waterproof chamber of its own, separated from the gearing, would remain long unaffected. As every contractor knows, the ability to work uninjured in a constant shower bath and when drowned is an important feature in a pump designed for shaft sinking.

All wearing parts of the machine are readily reached for examination and repairs, and can be easily and quickly replaced. There are no exposed moving parts which might hit and injure workmen, and the machine will stand hard usage without injury. Various sizes of the pump are manufactured, but a standard size suitable for general contractor's use has a capacity of 125 gallons per minute against a head of 200 ft. (about 7 HP.), weighs 3,000 lbs., and occupies a space $24 \times 26 \times 86$ ins.

THE LATEST PIPE CUTTING MACHINE.

The pipe cutting machine here illustrated is the invention of Mr. D. W. French, of the town of Union, N. J., and is already making an excellent record for itself as an effective, simple and economical tool for work of this description. The illustration here given shows practically all there is to the device from a mechanical standpoint. A revolving collar, made in three sizes to fit pipes from 4 ins. to 24 ins., carries a cutter around the pipe, and this cutter is automatically fed forward at each revolution by the contact of the star wheel on top of the cutter holder with a trip on the standing part of the machine. The collar is revolved by the rack upon it toothing with the gearing shown to the right of the cut, which is clamped firmly to the pipe in any desired position.

As the cutter holder is only 7 ins. high, the pipe can be cut in the trench if desired, and special patterns are made reducing this height to 3 ins. where the proximity of electric conduits and other obstructions makes this advisable. In cutting, the pipe, of course, remains stationary, the collar carrying the cutter alone revolving.



A NEW PIPE CUTTING MACHINE.

As to speed of cutting, it is said that one man can cut any pipe, after the machine is in place, and two men can handle the machine for any pipe up to 16 ins. According to a table given by the manufacturers and based upon experience, two men can cut a 4-in. pipe in 10 minutes, and five men can cut a 24-in. pipe in 40 minutes; with lesser sizes, to 10 ins. in 20 minutes.

A cracked pipe can be cut immediately at the point where the crack ceases, instead of 1 ft. beyond it, as is the ordinary method, and this foot of good pipe is saved. Pipe can also be cut on a bevel by manipulating the upper and lower set of screws in the cutter holder; and more important still, and by a simple change in the cutting tool, rounded grooves of any number can be cut in the end of the pipe to replace the bead in forming a leaded joint.

The illustration shows a solid machine, to be slipped over the end of the pipe; but they are now more generally made with a divided collar, permitting more extended use. This division is made on a line at right angles to the axis of the cutter, and consists simply of two flanges connected by bolts. Information as to prices and for machines larger than 24 ins. can be obtained by applying to Mr. Benjamin C. Smith, 275 Pearl St., New York.

THE BOUCICAULT BRIDGE.

The Boucicault Bridge, the principal details of which we illustrate in the accompanying cuts, reproduced from the "Annales des Ponts et Chaussees," was built in 1888-90 to carry a highway over the river Saone at a point about 10 miles above the town of Chalon, in the Department of the Saone and Loire, France. It replaced a ferry between Gergy and Verjux, and was constructed at the personal expense of Mme. Boucicault, who gave it to the public. At this point the river Soane is about 456 ft. wide, and its banks are but little above the level of ordinary high water. Its bed, as shown by borings, is composed of a sandy clay of variable consistency, and entirely unfitted to support masonry piers unless reinforced by pile foundations. These conditions and the requirements of navigation determined largely the design adopted for the bridge, which the donor desired to be a masonry arch structure. This design provided, as will be seen from the general elevation and plan (Fig. 1), for a bridge of five stone arch spans 40 m. (131.2 ft.) long, each, supported on stone masonry piers resting on pile foundations, and carrying a roadway 5 m. (16.4 ft.) wide, and two sidewalks each 1.5 m. (4.82 ft.) wide. The arches are of the catenary type, and have a rise of 5 m. (16.4 ft.) and a thickness at the crown of 1.05 m. (3.44 ft.).

Owing to the character of the river bed, it was decided to adopt pile foundations for both the piers and abutments. The pier sites were first dredged by a steam dredge to depths varying according to the location. This being completed, 136 spruce piles 0.35 m. (14 ins.) in diameter at their butts, and of sufficient heights to allow of a penetration of 8 m. (26 ft.) below the bottom of the dredged area, in case the point of refusal was not reached sooner, were driven for each pier. At this depth the average penetration under ten blows of a 1,200-kg. (2,640-lb.) hammer, falling 1 m. (3.28 ft.) was 0.01 m. (0.39 in.). This penetration was admitted to be too great for good practice, which places the maximum at 0.004 m. (0.157 in.); but with the conditions prevailing, it was impossible to obtain this limit, and the resistance was considered to be sufficient for the load. The arrangement of the piles in the pier foundations is shown in Fig. 8. After the piles were driven they were sawed off at a uniform level for each pier, and the voids between them, as well as the space for some distance around the foundation, filled with broken stone (Figs. 1 and 10). The concrete monoliths for the bases of the piers were built directly upon these enrockments, caissons being constructed for the purpose.

The general construction of these caissons is shown in Figs. 7, 8, 9 and 10. They were each 17 m. (55.75 ft.) long, 8 m. (26.2 ft.) wide, and 4.2 m. (13.75 ft.) deep, and were constructed and sunk into position as follows: The skeleton framework was first erected upon a platform of cross-timbers spanning the space between two barges anchored parallel to each other, and the necessary distance apart over the pier site. The position of this framework over the exact location of the caisson on the foundation being carefully assured, it was lifted by means of cranes; the supporting timbers removed, and then allowed to sink slowly. Before the framework was finally in position, a sheathing of 0.05 m. (2 ins.) square strips was placed on the inside of the upper part, as shown in Fig. 10 and thoroughly calked. The sinking was then completed, the framework firmly settled on the broken stone, and the sheet piling driven. Additional broken stone was then placed both inside and outside of the completed caisson, and everything was ready for the immersion of the concrete.

For placing the concrete a 0.4 m. (16 ins.) square wooden tube carried on a traveling crane was used. The travel of this crane was transversely across the caisson on a rolling platform, which ran lengthwise of the caisson on tracks on its sides. By this arrangement the tube could be moved in any direction desired. The tube itself was built in sections coupled together in such a manner as to be easily separated, and was provided with a funnel-shaped hopper for the insertion of the concrete. The method of operating the tube and placing the concrete was simple. The tube being provided with a detachable cover or bottom, was gradually filled with concrete and lowered into the water. When the bottom of the tube had reached a depth of about 0.4 m. (16 ins.) above the bottom of the caisson, the detachable bottom was removed, allowing the concrete to run out. Beginning at the upstream end, the tube was slowly moved across the caisson, then carried downstream the necessary distance, and then across the caisson in the opposite direction. This was repeated until a layer of concrete about 0.4 m. (16 ins.) thick covered the entire bottom of the caisson. The tube was then raised about 0.4 m. (16 ins.), a section at the top removed and another layer of concrete placed in exactly the same manner as the first. The concrete base was thus built up in 0.4 m. (16-in.) layers. In addition to leaving a very even top surface this process was claimed to have done away largely with "laitance," a term which French engineers apply to the well known gelatinous fluid washed from the cement, which is so detrimental to homogeneity in concrete construction under water. The amount of concrete placed daily by this apparatus was from 70 to 80 cu. m. (90 to 100 cu. yds.). The monolith for each pier contained about 400 cu. m. (520 cu. yds.), and it was allowed to set about a fortnight after completion before being disturbed. The thickness of the concrete base was uniformly

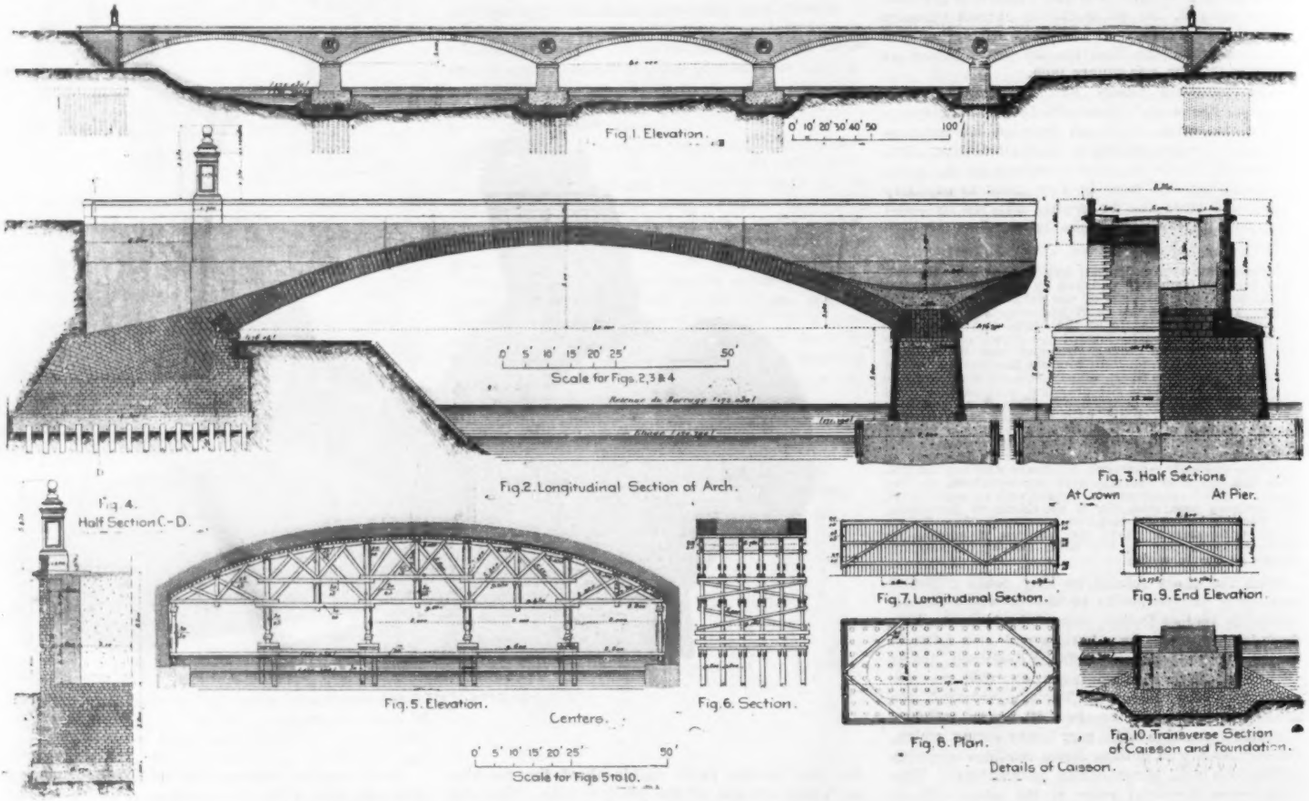


Fig. 1. Elevation.
0' 10' 20' 30' 40' 50 100'
0' 5' 10' 15' 20' 25' 50'
Scale for Figs. 2, 3 & 4
Fig. 2. Longitudinal Section of Arch.
Fig. 3. Half Sections
At Crown
At Pier.
Fig. 4.
Half Section C-D.
Fig. 5. Elevation.
Centers.
Fig. 6. Section.
Fig. 7. Longitudinal Section.
Fig. 9. End Elevation.
Fig. 8. Plan.
Fig. 10. Transverse Section of Caisson and Foundation.
Details of Caisson.
0' 5' 10' 15' 20' 25' 50'
Scale for Figs. 5 to 10.

GENERAL PLAN AND DETAILS OF THE BOUCICAULT BRIDGE; M. JOZON, CHIEF ENGINEER.

For placing the concrete a 0.4 m. (16 ins.) square wooden tube carried on a traveling crane was used. The travel of this crane was transversely across the caisson on a rolling platform, which ran lengthwise of the caisson on tracks on its sides. By this arrangement the tube could be moved in any direction desired. The tube itself was built in sections coupled together in such a manner as to be easily separated, and was provided with a funnel-shaped hopper for the insertion of the concrete. The method of operating the tube and placing the concrete was simple. The tube being provided with a detachable cover or bottom, was gradually filled with concrete and lowered into the water. When the bottom of the tube had reached a depth of about 0.4 m. (16 ins.) above the bottom of the caisson, the detachable bottom was removed, allowing the concrete to run out. Beginning at the upstream end, the tube was slowly moved across the caisson, then carried downstream the necessary distance, and then across the caisson in the opposite direction. This was repeated until a layer of concrete about 0.4 m. (16 ins.) thick covered the entire bottom of the caisson. The tube was then raised about 0.4 m. (16 ins.), a section at the top removed and another layer of concrete placed in exactly the same manner as the first. The concrete base was thus built up in 0.4 m. (16-in.) layers. In addition to leaving a very even top surface this process was claimed to have done away largely with "laitance," a term which French engineers apply to the well known gelatinous fluid washed from the cement, which is so detrimental to homogeneity in concrete construction under water. The amount of concrete placed daily by this apparatus was from 70 to 80 cu. m. (90 to 100 cu. yds.). The monolith for each pier contained about 400 cu. m. (520 cu. yds.), and it was allowed to set about a fortnight after completion before being disturbed. The thickness of the concrete base was uniformly 3 m. (9.84 ft.). Like the piers, the abutments were built upon pile foundations with a concrete cap. The number of piles used for each abutment foundation was 168, and the thickness of the concrete cap was 1.2 m. (3.93 ft.).

Details of the construction of the stone masonry work of the piers and abutments are shown in the longitudinal section of the left end arch, Fig. 3. The footings, cordons and skewbacks of the piers are cut stone. All the other facing is hammer dressed ashlar, and the backing is coursed rubble laid in hydraulic lime mortar. Between the skewbacks, which receive the thrusts of the arches on each side of the piers, the masonry is of large, hammer dressed stones, set on their edges in cement mortar. In the abutments, the quoins, cordons and skewbacks are cut stone, the other facing of dressed ashlar, and the backing of coursed rubble. To the rear of the springers were placed seven courses of dressed ashlar blocks, as shown in Fig. 2, practically continuing the arch and distributing the pressure over a greater area. For the same reason the rubble masonry back of the ashlar blocks is laid in inclined courses of gradually decreasing inclination toward the horizontal.

The construction of the centers upon which the arches were built is shown in Figs. 5 and 6. Each center was composed of six trusses, placed 1.6 m. (5.25 ft.) apart, c. to c. The trusses were divided into five panels of 8 m. (25.6 ft.) each, by six posts, four of which rested on wedges, supported on small piers consisting of two piles capped with a heavy timber, and two on the concrete monoliths of the piers. The pile piers were firmly braced longitudinally and transversely, and the trusses were also braced together, as shown in the illustrations. Some trouble was experienced by the settling of this center in one or two cases, but no damage resulted to the masonry, owing to the precautions taken to provide against further movement as soon as it was noticed. The cause of the settlement was considered to be the bending of some of the pier piles which had not been driven vertically, and were thus subjected to a bending strain.

The method of constructing the arch masonry was similar to that used in constructing the 196.8-ft. span arches of the Gour Noir Viaduct described in our issue of Aug. 18, 1892. This method is considerably favored by French engineers in the construction of long-span masonry arches, and consists briefly in dividing the arch masonry into several sections, or arcs, separated by timber supports, which are removed and the voids filled after the remainder of the arch is completed. The arches of the Boucicault Bridge were constructed in six sections each, thus leaving seven void spaces to be filled. Two of these were at the springings, one at the crown and one directly over each of the four intermediate posts of the centering. The supports near the springing lines were constructed as shown in Fig. 11. The lower of the wedges (a. a.) abutted directly against the skewbacks. The other supports were made of 0.05 m. (2 ins.) square joists supported by brackets abutting against blocks bolted to the centering. In closing the arch, the void at the crown was first filled. The other voids were then filled, proceeding from the crown toward the springing lines. It should be stated that before the masonry was begun the positions of the joints were carefully marked on the lagging of the centering.

The arch masonry was entirely of Villebois stone, cut to dimensions, and laid in cement and sand mortar, in the proportion of 600 kilos (1,320 lbs.) of quick-setting Vicat cement per 1 cu. m. (1.3 cu. yds.) of sand. The mean compressive strength of Villebois stone is 1,096 kilos per sq. cm. (15,713 lbs. per sq. in.). The thickness of the vousoirs at the intrados is 0.589 m. (1.93 ft.), including the joints, which are 0.008 m. (0.3 in.) thick.

The construction of the spandrel walls is shown in Figs. 3 and 4. They consist of a stone masonry facing from 0.8 m. (2.62 ft.) to 0.6 m. (1.96 ft.) thick, with a concrete backing. The concrete was of an inferior quality; being in the proportion of 100 kilos of hydraulic lime per cu. m. of river sand (220 lbs. per 1.3 cu. yd.). The parapets are of cut stone, and carved medallions are placed above each pier. The spandrel filling is gravel. Drainage pipes are placed near the springing lines and midway in the haunches of each arch.

The striking of the centers was accomplished as follows: Jacks were placed upon the transverse beams supporting the wedges and elevated to relieve the pressure upon the wedges. Forty-eight of these jacks were used for each center. The wedges were then removed, and the centering gradually lowered by the jacks. The deflections of the various arches were as follows:

Arch No.	1	0.044 m.	1.73 ins.
" "	2	0.013 m.	0.41 in.
" "	3	0.018 m.	0.70 in.
" "	4	0.011 m.	0.43 in.
" "	5	0.014 m.	0.55 in.

The deflection of arch No. 1 was abnormal, owing to the centering being removed too soon, and the fact that the bridge was unequally loaded at the time of performing that operation. The deflections of the other arches were very moderate.

The total length of the bridge is 234 m. (767 ft.), and the area of the plan, measuring from out to out of the parapets, is 2,072 sq. m. (2,466 sq. yds.) Its cost, excluding the services of the engineers, which were donated by the Department, was 486,000 ft. (97,200). Thus the cost per lineal metre was 2,077 fr. and per square metre of area of plan, 234 fr. This corresponds to a cost of $127 per lineal foot, and $39 per square yard of area. The work of construction was carried out under the direction of the government engineers; M. Jozon engineer-in-chief.

FAST TUNNEL DRIVING IN MEXICO.

Mr. Fred W. Abbott, Assoc. M. Am. Soc. C. E., Chief Engineer for Messrs. Read & Campbell, contractors for the Tequixquiac drainage tunnel, sends us the following letter describing recent rapid work on that tunnel. A full description of the work on which Mr. Abbott is engaged was given in our issues of Aug. 10, 1889, and Nov. 1, 1890:

We are now averaging in our heading in No. 12 shaft south, 39 ft. per 24 hours, and have on two or three occasions done as much as 24 ft. in 24 hours. We are working 8-hour shifts, with no let-up at the face. The ground has been just hard enough to require dynamite, but has had to be carefully timbered, as we go along, with settings every 3 ft., and inch boards on the sides and top. Besides this, we have carried along into the heading a 2 ft. drain below the level of the bottom of the treading, to carry away water. The cost, including labor at the face, movement of dirt below and above, explosives, lights, timber, etc., but excluding winding and pumping, has been about $20 American gold.

Every inch of this work is pickwork, and we have never had a machine on the work. The unreliability of the ground has prevented the use of drills of any kind; for instance, in this very heading, in a distance of ¼ mile, we have had soapstone, bowlders, sand and tepetate. At present, however, the ground is very good hard tepetate, with about 150 gallons of incoming water, and it is in this ground that we are able to make the above progress, which is, I think, equal to anything ever done by hand work.

ELEMENTS OF WEATHER IN THE UNITED STATES OF MOST INTEREST TO ENGINEERS FOR THE MONTH OF APRIL, 1893.

[Furnished to Engineering News by the Department of Agriculture.]

	Station.	Temperature. (Deg. Fahr.) Average	Max.	Min.	Range.	Wind. Velocity in miles per hour. Average	Max.	Direction at time of max. velocity.	Precipitation—rain and melted snow—inches. Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	36.4	62	11	51	12.3	44	S	1.63	0.62	15
	Portland, Me.	39.0	61	19	42	9.0	26	NW	3.71	1.44	16
	New York, N. Y.	47.8	70	32	38	11.7	40	NE	6.36	2.23	15
	Pittsburg, Pa.	51.4	80	32	48	9.1	36	SE	4.94	0.83	20
	Chicago, Ill.	44.4	84	27	57	23.9	72	NE	4.16	1.32	16
	Omaha, Neb.	48.4	82	25	57	11.7	48	NW	3.12	1.60	11
	St. Paul, Minn.	39.0	72	19	53	10.2	31	NW	5.30	1.63	11
	Duluth, Minn.	33.4	54	18	36	9.8	34	NE	3.64	1.74	13
	Bismarck, N. Dak.	36.5	65	6	59	12.5	49	NW	0.69	0.24	9
	Average	41.8	71	21	49	12	43.3		3.73	1.29	14
Southern Cities.	Washington, D. C.	53.8	84	35	49	8.2	38	NW	3.21	0.79	15
	Louisville, Ky.	57.4	83	33	50	9.4	48	W	7.69	1.43	21
	St. Louis, Mo.	56.6	88	33	55	13.8	54	SW	10.84	2.86	15
	Savannah, Ga.	70.0	89	51	38	9.8	32	S	2.20	1.35	3
	Leavenworth, Kan.	53.4	91	28	63	13.9	50	NW	3.85	1.65	12
	Jacksonville, Fla.	72.6	90	53	37	8.0	45	SW	2.67	2.54	3
	Chattanooga, Tenn.	63.8	86	37	49	7.3	36	SW	5.88	2.77	17
	New Orleans, La.	71.6	84	55	29	10.1	48	N	3.70	2.88	2
	Memphis, Tenn.	65.2	90	38	52	9.6	43	NW	5.48	1.76	11
	Palestine, Tex.	70.2	92	42	50	9.2	45	NW	3.37	2.42	4
	Average	63.5	87.7	40.5	47.2	9.9	43.9		4.89	2.05	10
Western Cities.	Helena, Mont.	38.8	67	16	51	8.0	37	SW	2.31	0.80	14
	Port Angeles, Wash.	44.8	58	30	28	5.6	28	W	3.70	0.84	17
	San Francisco, Cal.	52.4	72	40	32	12.4	42	SE	1.03	0.71	7
	Salt Lake City, Utah.	45.9	72	26	46	8.0	60	SW	2.72	0.82	12
	Denver, Colo.	45.1	77	13	64	10.0	36	NE	0.87	0.41	5
	Yuma, Ariz.	69.4	96	45	51	9.2	44	W	0.09	0.09	0
	Santa Fé, N. Mex.	47.8	70	19	51	9.3	44	SW	0.01	0.01	1
	Average	48.9	73.1	27	46.1	8.9	41.6		1.52	0.51	8

CONSTRUCTION NEWS.

RAILWAYS.

East of Chicago.—Existing Roads.

ALTOONA & PHILIPSBURG.—The contract for building this road from Philipsburg, southwest, through Houtzdale and Jamesville, to coal mines, 22 miles, has been awarded to E. A. Tennis, Thompsontown, and the grading has been commenced; Pres., S. P. Langdon, Philadelphia; Ch. Engr., W. F. Forsythe, Altoona.

BEECH CREEK.—Surveys have been completed for the extension of this road to Lock Haven, Pa.

BALTIMORE & CUMBERLAND.—The construction of this road has been commenced at the foot of Knobley, W. Va., near Cumberland, where there is to be a cut 400 ft. long and over 50 deep. The force will soon be increased to 500 men. This road is the eastern extension of the West Virginia Central & Pittsburg.

BALTIMORE & HARRISBURG.—The eastern extension of this road has been completed to near York, Pa. The work train is now below Thomasville, about seven miles distant.

TOLEDO & OHIO CENTRAL.—The work of constructing this road between Ridgeway and Marysville is progressing rapidly. The grade is finished six or seven miles from Ridgeway, and the road has been completed part of the way.

PITTSBURG, AKRON & WESTERN.—The contract has been awarded for the extension of this road eastward from Akron. The surveys have already been made, and it is intended to have the road completed to New Castle, Pa., by next January.

PENNSYLVANIA.—The engineers of this company have made a second survey of the proposed Monongahela River line, from the main line in the Connellsville region to Fairmont, and possibly to Charleston. The construction is expected to begin this summer.

LAKE ERIE, ALLIANCE & SOUTHERN.—According to press reports this road will be extended this summer from Bergholtz to Steubenville, and from Phalanx to Lake Erie.

CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS.—The directors of this road have voted to extend the line to Louisville, Ky., and Jeffersonville, Ind., directly across the Ohio River, which will necessitate the construction of a bridge at this place.

WHEELING & LAKE ERIE.—Surveys are being made for a branch of this road from near Laurelton up Dry Run of Short Creek to the Smithfield coal fields.

MICHIGAN.—John Fitzgerald & Co., Lincoln, Neb., have been awarded a contract for the construction of a railroad from Grand Rapids to Grand Haven, from which point a line of steamers will be run to Chicago. The contracts include the building of the steamers, and the price as reported is between $3,000,000 and $4,000,000.

PARRY SOUND.—Work on this road between Ottawa and Arnprior is being rapidly pushed, and passenger trains will probably be run regularly by next month.

NEWFOUNDLAND.—It is reported that Wm. G. Reid, Montreal, has been awarded a contract by the Newfoundland Government for a road from near Exploit through the interior of the island, touching the northeastern end, Grand and Deer Lakes, following the course of the Humber River, tapping the Bay of Islands, Bay St. George, and running to Port aux Basques on the southwestern extremity of the island, and the nearest point to Cape Breton. The road will be about 200 miles in length, and is to be completed in four years. The contract price is $15,000 a mile. Mr. Reid is now building 200 miles of road for the government, from St. John's toward Hall's Bay.

Projects and Surveys.

NEW YORK & MIDDLE COALFIELD.—This company, which was chartered in 1868, and again in 1892, proposes to build a railway from the Catawissa road to a point near Mt. Carmel, Pa.

CENTRAL R. R. OF PENNSYLVANIA.—Work will be commenced at once on this road, extending from Bellefonte to Mill Hall, a distance of about 30 miles. All the money to build and equip the road has been subscribed, and the right of way secured, and the contractors are under bonds to have the road in condition to operate inside of six months. This road will connect at Mill Hall with the Reading system, and will thus give Bellefonte a competing line with the Pennsylvania.

BLACKWATER VALLEY.—This company has completed its preliminary organization by electing C. C. Coffin, Boston, Mass., president. The road is projected to run from Mastyard Sta., near Concord, N. H., northwest through the Blackwater Valley, entering the towns of Webster, Salisbury and Andover.

LAKE SUPERIOR & ALGOMA COLONIZATION.—The railway committee of the Ontario Legislature has passed an act incorporating the above company. The road is to extend from the mouth of the Batchewaung River to the North Channel, near the town of Thessalon.

CAMDEN, GLOUCESTER & WOODBURY.—Chartered in Pennsylvania to build a railway from Camden to Woodbury, Pa. A. Townsend, Gloucester City, N. J.; Morgan D. Baird, Camden, N. J.; Geo. H. Barker, Woodbury, N. J.

Southern.—Existing Roads.

CHARLESTON, CINCINNATI & CHICAGO.—The property of this company has been sold to Chas. E. Heller, of Boston, Mass., representing the bondholders of the company. It is reported that a movement

will be made toward completing the road, as noted in our issue of April 20.

CALDWELL & NORTHERN.—The contractors for the grading and tracklaying on the first 20 miles of this road are Dunavant, Corpening & Miller, who have a large force of men at work. Their headquarters will be at Lenoir, N. C. The road is to extend through Edgefield county, from Lenoir to Caldwell. The Chf. Engr. is T. Montgomery.

KENTUCKY CENTRAL.—The company has let to Thos. Woods, of Covington, Ky., a contract for building a branch line to connect with the Louisville & Nashville R. R. bridge across the Ohio River at Cincinnati.

ATLANTIC COAST LINE.—It is reported that the railway from Cheraw to Wadesboro has been purchased by this system, and that a North Carolina extension will be built.

Projects and Surveys.

CHATTANOOGA & WESTERN.—A permanent organization of this company was effected May 8, the meeting of directors taking place in the offices of the Chattanooga Co., Ltd. After discussing the plans of the company, the following officers were elected: T. J. Nicholl, Pres.; T. D. Young, Vice-Pres.; H. C. Beck, Secy., and John Orr, Treas. A charter was obtained by the company some time ago. This is the line which is proposed to run from Chattanooga to Walden's Ridge, across the combination bridge over the river, a distance of 25 miles, and south to Bridgeport, with a spur to connect with the Cincinnati Southern; the entire line as planned to be about 75 miles in length, for the purpose more especially of tapping the coal and iron ore fields.

Northwest.—Existing Roads.

CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA.—The contract for building the extension from Ponca to Newcastle, Neb., 15 miles, has been let to Winston Bros., of St. Paul, Minn. Work is to be commenced at once, and it is expected to have the line completed in 60 days.

DULUTH, MISSISSIPPI RIVER & NORTHERN.—This company is operating 22 miles of line, 15½ miles of which is main line, extending from Mississippi River at mouth of Swan River, northeast to the north side of sec. 3, T. 45 N. R. 22 W. The remaining 6½ miles is a logging branch, leaving the main line in sec. 16 T. 54 N.—R. 22 W., ending near ¼ stake, on west side of sec. 19, T. 55 N. R. 22 W. The traffic so far has been mainly lumber; the company, since beginning operations last fall, have hauled in the neighborhood of 35,000,000 ft. B. M. of sawn logs, unloading them at the "banking" ground at the Mississippi River. The road is laid with steel rails weighing 45 lbs. per yard, and angle bars weighing 22 lbs. per pair. Tamarac ties (6×6 in. × 8 ft.) are used almost exclusively; 2,800 ties to the mile. The bridges and culverts are all timber structures. With the exception of two 50-ft. spans across Swan River, there are no bridges of any account. White pine is exclusively used for bridges and culverts. The company has 27 miles of new work now under contract, 17 miles of it being an extension of main line, which will complete the road to a point in sec. T. 57, N. R. 21 W. From this point a 10-mile branch line is being built to a point in sec. 23, T. 58 N. R. 20 W. This branch taps the western end of the Messabi Iron Range, and will develop considerable mineral land. Work on the line is all light, averaging about 15,000 cu. yds. per mile, with scarcely any classified material. Maximum grades, 1%; max. curves, 3°. Grading is expected to be completed Aug. 1, 1893. W. A. Dafter, Ch. Engr., Swan River, Minn.

CHIPPEWA FALLS & NORTHERN.—Surveys will begin in about 30 days for the line from Cadott, Wis., north, to a connection with the Minneapolis, St. Paul & Sault Ste. Marie Ry. Ch. Engr., S. F. Crabbe, Chippewa Falls, Wis.

JACKSONVILLE SOUTHEASTERN.—The people of Carlyle and Wisetown, Ill., have raised the $25,000 bonus necessary to secure the construction of the extension from Greenville to Carlyle, Ill., 27 miles. It is expected that work will begin soon.

BRAINERD & NORTHERN MINNESOTA.—The Minneapolis "Tribune" says: "Chf. Engr. Arms, of the Brainerd & Northern Minnesota R. R., which is being constructed into the interior of the state in the Leech Lake direction, was in the city recently on business connected with the line. He states that the definite location has been completed to the shore of Leech Lake, from the present terminus, which is near Pine Mountain Lake, over half the distance from Brainerd. The company has been operating about 50 miles of line ever since last fall, and will complete as much more as is possible this fall. A portion of the present line is to be moved a few miles eastward from its present location in order to secure an easier grade. The actual point of reaching Leech Lake will probably depend somewhat upon where the Great Northern line from Park Rapids strikes it, as both lines would most naturally touch at the same point. The bad weather has operated to greatly hinder work so far this spring."

Projects and Surveys.

DULUTH GREAT WESTERN.—The Duluth "Herald" says: "J. B. Holmes, vice-president of this company, formerly the Duluth, Red Lake Falls & Northern, was in Minneapolis recently and was interviewed. He stated that financial and other arrangements were all completed to begin work immediately. He had even been up the line to see what was the prospect for getting to work; as to the condition of the country along the line, he found that, however, very discouraging. Their line northwest from Duluth, as it has been located, lies through an immensely timbered tract as soon as they reach the valley of the St. Louis, and continues so until they pass the water-shed over to the Mississippi. In this part of the line there is no place where work can be begun to advantage for a long time yet. The snow is still 3 ft. deep in the timbered country. Mr. Holmes declared that they would go on and do as much as possible, and that next season would see the whole line completed at any rate. This line runs from Duluth to Red Lake Falls, north of Leech Lake, crossing the Grand Rapids point 15 miles north, or above that point."

Southwest.—Existing Roads.

RUDDOCK, BONNET, CARRE & NORTHERN.—The Ruddock Mfg. Co. have begun the construction of a railway by this name. Headquarters, Ruddock, La.

MISSOURI, KANSAS & TEXAS.—It is reported that this company will build a line from Henrietta to Luxemburg, Tex., within the next four months.

CHICAGO, ROCK ISLAND & PACIFIC.—Only 12 miles more of grading remain on the extension from Bowie to Ft. Worth, Tex.

WEATHERFORD, MINERAL WELLS & NORTHWESTERN.—A press dispatch says: "The surveying party which started out from the terminus at Mineral Wells, Tex., some two or three weeks ago are now beyond Christian, going in a northerly direction. The line from Mineral Wells to Christian is a good one, and satisfactory to the company, and if as satisfactory a line can be found on for a good way in the northwest, the road will, no doubt, be extended right away. The road is doing an excellent cattle shipping business. There is scarcely a day but what it makes a large shipment of cattle."

TEXAS.—The "Manufacturers' Record" gives the following summary of railway construction in Texas. Most of these enterprises have already been mentioned in our railway columns: "Texas is rapidly coming to the front as a railway-building state. At present, new lines are being planned or built in nearly every part of Texas where transportation facilities are needed. Although a number of roads have been completed within the past year, the ones on paper and partly constructed are still numerous, and the demand for railway material from southwest corner of the country bids fair to be heavy for a year or more at least. One of the most important of the schemes is the building of a line from Waco, near the center of the state, through the eastern pine lands to Cheneyville, where connections would be made with the Texas Pacific and Southern Pacific systems. From that point it is planned to continue to New Orleans. The proposed road to Cheneyville would be about 150 miles in length. Waco capitalists are pushing the matter, and have held several meetings, at the last of which a committee was appointed to have preliminary surveys made. A line about to be constructed is the Fort Worth & Albuquerque, from Fort Worth to Albuquerque, N. M., a distance of 110 miles; 13 miles of it have been graded already. It will pass through a country which is said to be rich in coal and other minerals, and will open up a large agricultural section, and tap the Atchison, Topeka & Santa Fe system at its Albuquerque terminus. Another move in railway extension is the action of the directors of the Texas & New Orleans branch of the Southern Pacific, who favor issuing $4,195,000 in bonds, part of which is to be used in extending the line to Marshall, Tex., by way of Tyler, Henderson, Nacogdoches and San Augustine. The businessmen of Houston are reported as heartily in favor of the idea. The railway extends at present from Houston to the Sabine River, a distance of 192 miles. The Marshall extension would be about 45 miles in length.

"A recent survey has been completed for a line to be built between Gainesville, Tex., and the coal mines, about 75 miles distant. Such a road would pass through Dexter, Tishimingo and Coal Gate, and penetrate an excellent farming country. The idea of the projectors is to have the road merged with the Huntington or Santa Fe system. Bonds will be issued for building the road at the rate of $20,000 per mile."

Projects and Surveys.

LAUREL VALLEY & ROSSEAU STATION.—This company has been chartered in Louisiana to build a railway, commencing on the public road in front of the Laurel Valley plantation, about three miles below Thibodaux, on the east side of Bayou Lafourche, passing by the sugar refinery on the said plantation, thence down and parallel to the said bayou to Rosseau, on the Southern Pacific R. R., about seven miles below the town of Thibodaux. The capital stock of the company is fixed at $15,000. Wilson Lepine, Frank Barker, and Alexander Theriot, with Mr. Lepine Gen. Man., and Mr. Barker Secy. and Treas.

Rocky Mt. and Pacific.—Existing Roads.

SOUTHERN PACIFIC.—It is rumored that this company will build a line from Yuma, Ariz., to San Diego, Cal.

CALIFORNIA & NEVADA.—The new management states that this railway will be changed to a standard gage at once.

Projects and Surveys.

INDEPENDENCE & SALEM.—This company has been incorporated at Salem, Ore. The incorporators are J. A. Veness, J. M. Vanduyn, R. D. Cooper, J. M. Stark and Philip Metschan. Ten miles of road will be built this year, starting from Independence, and reaching the Salem bridge, in Polk county. It will be a standard-gage line, with 50-lbs. rails.

STILLAGUAMISH VALLEY.—This company has been organized to build a railway from the Seattle, Lake Shore & Eastern R. R., at Haller City to the Sauk River.

WHITE & COLUMBIA RIVER.—Chartered in Washington to build a railway from Buckeye, up the White and Greenwater rivers, to the Columbia River. Incorporators: C. W. Joynt, S. H. Hart, E. Van Alstine.

SAN DIEGO & PHOENIX.—The preliminary surveys for this road have just been started from both San Diego and Yuma, Cal. Considerable right of way has already been secured near San Diego, and the right of way through Arizona is also promised. A prospectus issued by the projectors gives some details of the company. Two charters have been secured—one in California and the other in Arizona, both under the same name. Four hundred thousand dollars of the capital stock of the California company is reported subscribed, and $350,000 of the stock of the Arizona company. The California line will extend from San Diego through the New River Valley, and the Jacumba and Jamul valleys of California, to Yuma, 175 miles, and the Arizona section from Yuma through the Salt River, Mohawk and Gila valleys to Phoenix, 125 miles. D. C. Reed, of San Diego, is President, and H. G. Morrell, Secretary, of both companies.

KASLO & SLOCAN.—Preparations are being made for the immediate construction of the railroad from Kaslo, B. C., on Kootenai Lake, west to the Slocan mines. D. J. Munn, of Victoria, and J. Hendry, of New Westminster, B. C., the projectors of the line, state that they have secured a charter from the Dominion government, and are all ready to commence work on the line. The eastern terminus will be Kaslo, but the western terminus is not definitely decided. The line will touch at some point on Slocan Lake. Several surveys have been made, and the first 20 miles of the road have been definitely located from Kaslo to Bear Lake, at the forks of Carpenter Creek. The entire line will be about 30 miles long. Work will commence on the east 30 miles immediately.

Foreign.

TEHUANTEPEC.—The government appropriation of $2,000,000 for the construction of the Tehuantepec Isthmus R. R., will be expended May 15, and all work on the line will then be suspended until further appropriation is made. It is estimated that $1,000,000 will be required to finish the road. About 350 men are employed on the south end of the road.

CONTINENTAL.—The concession granted to the Continental Ry. Co. Nov. 9, 1889, for the construction of six lines of railway between Matamoras and the Guatemalan frontier, following the Gulf coast, touching the port of Tuxpan and crossing the Tehuantepec Ry. has been declared forfeited. One-half of the money put up by the company as guaranty deposit will be returned to it. The other half will remain to the benefit of the public treasury.

ELECTRIC RAILWAYS.

ORANGE, MASS.—A franchise has been granted to the Athol & Orange Electric St. Ry. Co. for a line between the places named.

BROOKLYN, N. Y.—The Brooklyn City R. R. Co. has made application to the town board of Newtown for permission to lay tracks along Thompson Ave., the old shell road, the trotting course lane, Jamaica road to Hoffman boulevard, Calvary Cemetery road, and other streets from Jamaica road to the line dividing the towns of Newtown and Jamaica, about 20 miles of additional track. The application, if allowed, will result in increased accommodations for the residents of Newtown, Flushing, Corona, Richmond Hill and Woodhaven.

MECHANICVILLE, N. Y.—The stockholders of the Stillwater & Mechanicville St. Ry. Co. have voted to change the motive power from horse to electric, and to increase the capital stock from $40,000 to $60,000, the change to be made at once.

CAMDEN, N. J.—The Camden, Gloucester & Woodbury Electric R. R. Co. has been incorporated to build an electric road between the places named. The power plant will be located at Gloucester, and the terminal points will be the race track and Thompson's new ferry, between this city and Philadelphia; $900,000; Wm. J. Thompson, Henry M. Harley, Abraham Townsend, of Gloucester.—A company has been incorporated by Henlings Lippincott, Chester; Howard Parry, Cinnaminson; S. E. Stokes, Philadelphia, and others, to build five lines of electric roads from their city; $3,000,000. The routes are as follows: Camden through Pavonia, Palmyra, Riverton, Riverside, Delanco, Beverly, Edgewater Park and Burlington, to Florence; Camden via the Westfield turnpike to Burlington; Camden to Merchantville, Moorestown and Stanwick; Camden to Collinsville, Haddonfield and Berlin; Camden to Mount Ephriam, encircling Camden.

SEA ISLE CITY, N. J.—J. J. Burleigh has been engaged to report upon the advisability of building an electric road along the ocean front, from Corson's to Townsend's Inlet.

BELLEFONTE, PA.—The Spangler & Hastings Electric Ry. Co. has been incorporated to operate a line between Spangler, Barnesboro and Hastings; $42,000; Pres., J. L. Spangler.

LANCASTER, PA.—It is reported that all the electrict lines in this county have passed into the control of a company represented by John J. Patterson. One result of this change of ownership will be the pushing to speedy completion of all the electric roads in contemplation in the county, making this city the center of the system.—Senator Patterson, the head of the purchasing syndicate which is building the Harrisburg & Philadelphia Electric Ry., reports that the right of way to within a distance of four miles of Philadelphia has been secured, and that the right for entrance into Philadelphia will soon be satisfactorily arranged. Work will begin about June 1.

WILKES BARRE, PA.—The Wilkes Barre & East Side Ry. Co. has been incorporated; $50,000; Pres., John Graham. The company proposes to build a five-mile electric railway to Pittston.

ELEVATED RAILWAYS.

BALTIMORE, MD.,—The Lake Roland Elevated Ry. Co. has been granted permission to construct a double track line in Baltimore county, from the city line along Roland Ave. to Lake Ave.

HORSE AND MOTOR RAILWAYS.

ALLENTOWN, PA.—The Bethlehem & Catasauqua R. R. Co. has been incorporated to operate a street railway between the places named; $60,000; Pres., Albert L. Johnson, Cleveland, O.

SHARPSBURG, PA.—The East End & Sharpsburg Ry. Co. has been incorporated to operate a street railway between East End and Pittsburg; $300,000; Pres., J. R. Davis, New York.

HOOPESTON, ILL.—The Hoopeston Ry. Co. has been incorporated to construct and operate a street railway; $40,000; J. P. Dyer, Dale Wallace, J. S. McFerren.

BRIDGES, TUNNELS AND CANALS.

UPPER MARLBORO, MASS.—The Agricultural Fair Association has decided to construct an iron bridge at this place.

MACON, GA.—The County Commissioners are considering the construction of an iron bridge across the Ocmulgee River. Estimated cost, $35,000.

GRAFTON, N. DAK.—Bids will be received until May 23 for an iron bridge. F. Worthing, Town Clerk.

JOPLIN, MO.—Bids are asked for the construction of a bridge. Address City Engineer.

HIGHWAYS.

NEW JERSEY.—The board of freeholders of Camden county has appropriated $85,000 for telford roads—The board of freeholders of Gloucester county has made appropriations amounting to $60,000, of which $10,000 will be used for building bridges. Edward G. Miller, Greenwich, is director of the board.

WATER-WORKS.

BANGOR, ME.—M. M. Tidd, Engr., Boston, has recommended a new supply main, including 12,800 ft. of 20-in. pipe, 3,780 ft. of 8-in., 42,270 ft. of 6-in. pipe, and a 100×40-ft. tank; estimated cost, $138,891.

CHICOPEE, MASS.—The water board will receive bids until May 27 for the construction of the new system. E. C. & E. E. Davis, Engrs., Northampton.

NANTUCKET, MASS.—The committee on water supply has reported in favor of new construction, estimated to cost $50,000. Ernest W. Bowditch, Engr., Boston.

NORTH BROOKFIELD, MASS.—The town has been authorized to increase the water loan $50,000, and the commissioners will borrow that sum.

EAST HARTFORD, CONN.—The East Hartford Water Co. will issue $100,000 of additional bonds, making $180,000 in all. The plant will soon be extended to the Meadow district. A. P. Moore, Supt.

BINGHAMTON, N. Y.—It is reported that four miles of mains will be laid this summer.

DUNKIRK, N. Y.—The water commissioners will receive bids until June 7 for furnishing and laying 5,200 ft., 522 tons, of 24-in. cast iron pipe; also for intake crib, well, etc. J. D. Cook, Consult. Engr., Toledo.

JAMESTOWN, N. Y.—The Jamestown Water Supply Co. will soon extend its mains to Falconer.

LOWVILLE, N. Y.—W. B. Rider, Engr., South Norwalk, Conn., has prepared plans for works estimated to cost about $65,000. It is thought that an election will soon be held to vote on the question of construction.

SIDNEY, N. Y.—It is reported that the Morris Water Co. has been incorporated and will put in works, to be ready for use in November.

NEW YORK, N. Y.—All bids received for furnishing engines, pumps, etc., for the high service pumping station at 181st St. and Amsterdam Ave. have been rejected, and new specifications are being prepared.

SOUTHAMPTON, N. Y.—It is reported that a local company has been organized, and that works will be constructed at once; capital stock, $75,000.

SOUTH ATRIM, N. H.—The taxpayers have authorized the commissioners to put in works, to cost not over $21,000. D. H. Goodell, Morris Christie and Henry Simonds were chosen as commissioners.

ORANGE, N. J.—The superintendent has been directed to advertise for bids for the trenching and 5,000 ft. of pipe.

MANSFIELD, PA.—A plant is to be put in by Amerman & Watres, Scranton, to be completed by Aug. 15.

AUSTIN, PA.—The Crystal Springs Water Co. has been incorporated to supply this place with water; $1,000; Treas., John L. Compton.

MOUNT CARMEL, PA.—The Mount Carmel Water Co. will construct a new reservoir on Locust Mountain, about two miles distant. Surveys will be made by Engr. Cochran, Pottsville.

NEWPORT, PA.—The Newport Home Water Co. has been incorporated by E. H. Leffler, Millersburg, to supply this town with water; capital stock, $1,000.

PHILADELPHIA, PA.—The board of directors of city trusts has appropriated $9,000 for a filter plant at Girard College.—The contract for the new boiler and engine house for the pumping station at Lardner's Point has been awarded to Thos. Gamon, at $75,500. Benner & Opdyke bid $97,800, and H. C. Nichols, $77,450.

PINE GROVE, PA.—Bids for constructing works are asked, as stated in our advertising columns.

SEWICKLEY, PA.—The Apollo Spring Water Co. has been incorporated; capital stock, $2,750; Treas., W. W. Scott. Works were built by the borough in 1871.

TOWER CITY, PA.—The Tower City Water Co. has been incorporated; $1,000; Treas., E. H. Leffler, Millersburg.

WAYMART, PA.—The Waymart Water Co. has been incorporated by A. L. Patterson, Carbondale; capital stock, $5,000.

LYNCHBURG, VA.—The committee on water has been directed to investigate the feasibility of a water supply by gravitation; appropriation, $500.

FORT GAINES, GA.—The city council is preparing to extend and improve the works, including the construction of a reservoir.

COLUMBUS, O.—The board of public works will receive bids for eight new boilers for the West Side pumping station.

HILLSBORO, O.—Bids are asked, in our advertising columns, for the construction of works.

MORGANFIELD, KY.—The city council is considering plans for works.

HAUGHVILLE, IND.—The village clerk has been instructed to ascertain from the Indianapolis Water Co. upon what terms the town could secure works.

ROCHESTER, IND.—The Fulton County Water Co. has been incorporated; $20,000; Daniel A. Green, H. A. Barnhart, L. C. Curtis.

LEBANON, IND.—The citizens have voted by a large majority to put in a system.

MARTINSVILLE, IND.—The contract for the construction of the proposed plant has been awarded to T. Hardman, Olney, Ill., at $11,150, not including wells and mains. The contract for pipe was recently awarded at $23.50 per ton, as noted in our issue of April 20.

NORTH MANCHESTER, IND.—It is reported that the contract for works has been awarded to C. S. Coon & Co., Upper Sandusky, O., and the Muskegon Boiler Works, Muskegon, Mich., at $2,200.

GRAND RAPIDS, MICH.—The Jenison Subterranean Spring Water Co. is being organized to supply water from an artesian well; $10,000; Henry A. Hydorn, Luman Jenison, John Barrager.

BELVIDERE, ILL.—It is reported that the city council will spend $6,000 for new mains.

MOLINE, ILL.—The city clerk will receive bids until June 14 for a pumping engine for the water-works; capacity, 5,000,000 gallons for 24 hours. Fred. Alsterlund, Ch. Engr.

GIBSON, ILL.—The question of water-works is being discussed by the citizens.

MOWEAQUA, ILL.—It is reported that sufficient money has been secured to insure the construction of works.

NEENAH, WIS.—Aldermen Kellogg, Garmanson, Zemlock, A. Jargerson, and the mayor have been appointed a committee to investigate the question of works.

KENOSHA, WIS.—The committee appointed to consider the bids for works has recommended that the contract be awarded to W. S. Reed & Co., Chicago. The bid calls for an annual rental of $7,800, and $45 for each hydrant on extensions.

COGGON, IA.—The question of works is being discussed.

GRAND RAPIDS, MINN.—It is reported that $15,000 will be spent for works.

LAKE BENTON, MINN.—The citizens have voted in favor of works; estimated cost, $3,000. C. F. Loweth, Engr., St. Paul.

SPRING VALLEY, MINN.—It is reported that works will be constructed.

HURON, KAN.—Plans are being prepared for a water supply from an artificial lake about a mile distant.

HUNTINGTON, NEB.—It is reported that $10,000 will be spent for works.

BANCROFT, NEB.—Bids are asked until May 27 for the construction of works. M. I. Ellis, Vil. Clk.

GRETNA, NEB.—It is reported that works will be put in.

EASTLAND, TEX.—The Eastland Water Co. has been incorporated; $10,000; C. U. Connellee and others.

GALVESTON, TEX.—The committee has recommended that the bid of J. W. Byrnes & Co., at $785,902, be accepted for the construction of the proposed plant. This bid did not include pumps, boilers and pumping-house. Holly vertical pumps, to cost $66,000, were selected. Bids will be asked for the construction of a pumping station.

GRAND JUNCTION, COLO.—The city council is considering a proposition to issue bonds for $100,000 to secure a water supply from the mountain lakes near the city. Works were built here in 1889 under a franchise, but the supply is inadequate and there is a desire for a municipal plant.

TELLURIDE, COLO.—Plans for a new reservoir have been adopted and sent to the state engineer for approval. It is hoped to commence the construction soon.

ASPEN, COLO.—A 20-year franchise has been granted to the People's Water Co. The supply will be from Difficult Creek, about 20 miles distant. The Castle Creek Water Co. built works here in 1886. Geo. S. Newman is interested in the new company.

PUEBLO, COLO.—The Pueblo Water-Works Co. has been incorporated by Robt. Gibson, C. E. Gast and others, of this city, and Chas. P. Allen, Ch. Engr., Citizens' Water Co., Denver; capital stock, $1,500,000. It is proposed to buy the two systems supplying the two sides of the town, and spend about $500,000 in improving and enlarging them. The supply will be from the Arkansas River, about 20 miles distant, and a 20,000,000-gallon reservoir will be constructed at a place three miles from the city, and having an elevation of 270 ft. The works are to be in operation before September, 1894.

PASCO, WASH.—The city council has granted a franchise to H. M. McCartney, Salt Lake City.

NEEDLES, CAL.—It is reported that works will soon be constructed.

SANTA ROSA, CAL.—The proposition to issue bonds for works to be owned by the city has been carried. It is proposed to put in Wagner steam filter wells.

KAYSVILLE, UTAH.—Works are being discussed.

MONROE, UTAH.—The town council is considering the question of works. It is reported that sentiment is much in favor of construction.

YARMOUTH, N. S.—The town has been authorized to purchase the works, and to issue bonds for $300,000. The council has voted to receive bids for $265,000 of bonds, $240,000 of which are for purchasing the works.

IRRIGATION.

CALIFORNIA.—It is reported that work will soon be commenced on the Lodi irrigation project, and that bonds will be sold to complete the work. L. W. Buck, Solano; Col. F. S. Chadbourne, San Francisco; B. F. Lanford and John R. Bothwell are among the newly elected directors of the Mokelumne Irrigation Co.

SEWERS.

BETHLEHEM, N. H.—Plans have been prepared by E. C. Jordan, Portland, Me., for about four miles of 8 and 6-in. pipe sewers, average cut 4 to 6 ft. The work will be done by day labor and contract.

RUTLAND, VT.—The city engineer is preparing plans for a sewerage system.

CHELSEA, MASS.—Orders have been adopted for 4,500 lin. ft. of sewers.

EASTHAMPTON, MASS.—It is reported that bids will soon be asked for 8,000 ft. of 8-in. and 1,200 ft. of 10-in. pipe.

NEW BEDFORD, MASS.—J. C. Brock, mayor, informs us that the city will soon contract for two short sewers, about 2,000 ft., as an experiment.

WEST NEWTON, MASS.—The contract for sections 6 and 8 of the sewer system have been awarded to Frank L. Allen, Worcester, at $30,617 and $8,740, respectively.

NEW LONDON, CONN.—The sewer board will soon advertise for bids for about 6,000 lin. ft. of 12 to 10-in. sewers.

BUFFALO, N. Y.—The department of public works will receive bids until May 24 for a 51 to 18-in. tile sewer in Military road.

FISHKILL LANDING, N. Y.—Bids are asked until June 15 for about 10,000 ft. of 12-in. sewer from the Matteawan State Hospital to the Hudson River. H. E. Allison, Med. Supt.

FLUSHING, N. Y.—The contract for a sewer in Myrtle Ave. has been awarded to E. E. Eagee, at $26,944. The other bids were as follows: Borden & Smith, Long Island City, $34,385; Newton & Conover, New York, $38,470; Tuohy & Co., Flushing, $32,847.

NEWBURG, N. Y.—The council is considering the proposed sewer in West Newburg. Everett Garrison, Acting Cy. Engr., informs us that there will be 9,400 lin. ft. of 5-ft. brick sewer and 2,600 lin. ft. of 24-in. pipe sewer; estimated cost, $136,000.

NEW ROCHELLE, N. Y.—Bids are asked in our advertising columns for two sections of the sewer system.

OLEAN, N. Y.—The city clerk will receive bids until May 26 for a pipe sewer in State St.

ROCHESTER, N. Y.—The East Side trunk sewer commission will receive bids until May 24 for University Ave. overflow outlet.

BUTLER, PA.—C. F. L. McQuiston, Engr., is preparing plans for extensions for the southwestern district of the city.

DU BOIS, PA.—The city council has engaged C. F. L. McQuiston, Butler, to make surveys for a sewerage system, work on a part of which will be commenced as soon as plans of system are completed.

OIL CITY, PA.—The city controller will receive bids until May 22 for three pipe sewers.

ROANOKE, VA.—Bids are asked until May 25 for several sewers. J. D. Kirk, Chn. Bd. Pub. Wks.

NEWPORT, KY.—Bids are asked until June 1 for sewers in five streets. B. R. Morton, Cy. Engr.

SPRINGFIELD, O.—The question of sewage disposal is being discussed by the board of trade. Two plans have been proposed.

INDIANAPOLIS, IND.—The board of public works will receive bids until May 26 for a main and local sewer.

TERRE HAUTE, IND.—The city engineer has been directed to prepare plans and specifications for a belt sewer to drain the northeast, east and southeast portions of the city; estimated cost, $200,000 to $250,000.

ISHPEMING, MICH.—Bids are asked in our advertising columns for about 16,500 lin. ft. of pipe and brick sewer.

MARQUETTE, MICH.—The city recorder has been directed to advertise for bids for sewers in two districts.

NEGAUNEE, MICH.—Bids will be received until June 15 for about 4.5 miles of 8 and 10-in. sewers. C. R. Wightman, Cy. Engr.

CHAMPAIGN, ILL.—The question for a sewerage system for this town and Urbana is being discussed. The "Gazette" urges that a system must be provided without delay.

JANESVILLE, WIS.—Plans have been prepared for a system, and a committee of ten, including C. S. Jackman and John Watson, appointed to investigate the subject.

WATERTOWN, WIS.—It is reported that a sewerage system will soon be adopted.

DES MOINES, IA.—A resolution has been adopted to construct a sewer in Bird's Run, 3,400 ft. in length; estimated cost, $23,000.

FREMONT, WASH.—The city council has decided to submit to a vote of the people a proposition to issue bonds for $250,000 for sewers.

TACOMA, WASH.—At the election May 9 the proposition to issue bonds for $500,000, referred to in our issue of April 20, was carried.

SACRAMENTO, CAL.—J. C. Pierson and J. C. Boyd, Cy. Engr., are members of a committee appointed to investigate the question of a sewerage system. Several plans have been proposed.

SALT LAKE CITY, UTAH.—The contract for the gravity sewer has been awarded to Houlahan, Griffith, Morris, Hobson & Wilkerson, at $307,327 for a brick and concrete sewer. The itemized prices were published last week.

STREETS.

BRADFORD, MASS.—The contract for paving Main St. has been awarded to Thos. Lahey, at $20,200.

NEW YORK, N. Y.—The commissioners of public works will receive bids until May 20 for five contracts for paving with asphalt, granite and macadam.—The department of parks will receive bids until May 24 for excavating asphalt paving, etc.

SYRACUSE, N. Y.—For paving Onondaga St., from Zalina to Mulberry St., with Trinidad Lake asphalt, the Warren-Scharf Asphalt Paving Co. bid $25,044, and the Syracuse Improvement Co. $22,217.

BALTIMORE, MD.—It has been decided to advertise for bids for paving one street with Belgian blocks; estimated cost, $60,000. This will be done as an experiment.

NEWPORT, KY.—Bids will be received until June 1 for paving four streets with brick; also for macadamizing. B. R. Morton, Cy. Engr.

BELLEVUE, O.—The village clerk will receive bids until May 31 for paving 6,780 sq. yds. with brick; estimated cost, $11,500. Smith & Laylin, Engrs., Norwalk.

CLEVELAND, O.—The contract for paving East Prospect St. with asphalt, with a 10-year guaranty, has been awarded to the Warren-Scharf Asphalt Paving Co., at $108,000.

DAYTON, O.—The city comptroller will receive bids until June 5 for paving about 90,000 sq. yds. with first class Medina stone blocks, Hayden blocks, Hallwood blocks, asphalt or brick.

RIVERSIDE, O.—Bids are asked until May 22 for the improvement of Maxwell Ave. Chas. A. Erring, Engr.

TIFFIN, O.—Bids for paving Perry St. with brick ranged as follows: Herron & Morehon, $45,474 to $57,322; McCloud & Geigle $45,011 to $54,287; Cuthbert & Stewart, $44,440 to $53,546; John E. King, $44,466 to $54,040; Louis Schonder, $44,837 to $54,710.

BRAZIL, IND.—The city clerk will receive bids until June 20 for three contracts for flagging, etc.

RICHMOND, IND.—Bids are asked until May 26 for paving Main St. with brick. C. G. Swain, Clk. Bd. Pub. Imprs.

GRAND RAPIDS, MICH.—Contracts for paving have been awarded to Jas. McDermott, at $31,000; A. Prang, two contracts, $13,140; Fred Van der Plow, $5,687. Estimates have been submitted for additional work to cost about $40,000.

MORMAL, ILL.—Bids will be opened June 1 for about 20,000 sq. yds. of paving with brick, 7,000 lin. ft. of sandstone curbing, and 8,000 cu. yds. of grading; also for 1,000 lin. ft. of 10 to 12-in. pipe sewers. E. Manley, Chn. St. Com.

GREEN BAY, WIS.—The council is considering ordinances for paving in seven streets.

KEOKUK, IA.—Bids are asked until June 1 for about 9,200 sq. yds. of brick paving, 4,500 lin. ft. of curbing and 4,500 cu. yds. of grading. W. H. Jones, Cy. Engr.

FARGO, N. DAK.—The citizens are discussing the paving of the principal streets.

MONTREAL, QUE.—The road committee has prepared a list of the streets to be paved this year. Asphalt and granite will be used, and the total estimate is $573,630. Proposed sidewalks will cost $117,452, of which the city will pay $40,972.

ELECTRICAL.

PHILADELPHIA, PA.—The board of directors of city trusts has appropriated $75,000 for an electric light plant at Girard College.

PHILADELPHIA, PA.—The Philadelphia & Rosemont Ry. Co. has been incorporated to operate an electric line between the places named; $150,000; Pres., Geo. A. Cook.

FREDERICK, MD.—A franchise for an electric railway between this city and Middletown, about eight miles, has been asked for by Geo. W. Smith and C. V. S. Levy. The estimated cost is $225,000, and preliminary surveys are now being made.

HICKORY, N. C.—It is reported that a plant will be put in by M. E. Thornton, the electricity to be generated by water power.

MACON, GA.—F. J. Carlin will build an electric railway to the lands of the Ocmulgee Land Improvement Co., two miles, and it is proposed to extend this to Indian Springs, Ga., 35 miles.

MOBILE, ALA.—The tracks of the Mobile St. R. R. Co. are being relaid preparatory to changing to the trolley. A site has been purchased for a new power house, car sheds, shops and offices. It is expected to have electric cars running by the last of July.

HILLSDALE, MICH.—Plans for a plant for 50 arc and 1,000 incandescent lights have been prepared by Frank B. Rae, Detroit. The plant is to be owned by the city, and bids for the construction will be opened June 4. Geo. A. Janes, Cy. Clerk.

MARSHFIELD, WIS.—The electric light contract has been awarded to the Marshfield Water, Electric & Power Co. for five years at $1,800 per year for 23 arc lights of 2,000 c. p., each light to burn from early twilight until midnight.

SHEBOYGAN, WIS.—The council has voted to put in 25 arc lights for street lighting. The Wisconsin Chair Co. has a plant, and, it is reported, will bid for the contract.

LEXINGTON, KY.—The court of claims of Fayette county has appointed a committee to investigate the feasibility of constructing an electric railway from this city to at least one of the towns in the Bluegrass region. It is proposed to build the first road to Paris, 18 miles, or to Versailles, 15 miles. It is claimed that the road to Paris could be built for $100,000.

BRIDGEPORT, O.—The Bellaire, Bridgeport & Martin's Ferry St. Ry. Co. has been incorporated to operate an electric street railway; $250,000.

KNIGHTSTOWN, IND.—It is reported that a company is being organized to build an electric road to New Castle, via Greensboro or Spiceland.

INDIANAPOLIS, IND.—The Citizens' St. R. R. Co., which operates all the lines in this city, has increased its capital stock from $1,000,000 to $5,000,000. The equipment of the road is being changed from horse power to electricity.

NEW COMPANIES.—United Electric Light & Power Co., Bayonne, N. J.; $50,000; M. R. Cook, C. E. Annet, J. H. Van Buskirk.—Hanover Light, Heat & Power Co., Hanover, Pa.; $25,000; Treas., J. W. Mumfer, Dillsburg.—Priceburg Electric Light Co., Scranton, Pa., $10,000; Treas., W. M. Jermyn.—Sloss-Stein Electric Co., Chicago, Ill.; $50,000; Sidney Stein, M. Sloss, Louis Stein.

CONTRACT PRICES.

SEWERS.—Port Plain, N. Y.—We are informed by De Witt C. Smith, Engr., Schenectady, that the contract for a system of sewers has been awarded to Small & Gallo, New York, at $15,895, the other total bids being: Michael Sullivan, Little Falls, $19,178; McDonald, Nicholson & Co., Port Huron, Mich., $19,502; John Morrell, Mohawk, $21,189; John Marsden, Utica, $21,376; P. H. Harrison & Son, Newark, N. J., $21,660; C. B. & F. A. Cadwell, New Britain, Conn., $25,509; Jas. McDonald, Little Falls, $29,765; R. H. Strong, Albany, $33,579. The contract prices were as follows: 20-in. vitrified pipe sewer, complete, 1,150 lin. ft., $1.68¾ per lin. ft.; 15-in., 2,350 lin. ft., 63¼ cts.; 8-in., 25,200 lin. ft., 32 cts.; 6-in. 3,100 lin. ft., 22½ cts.; 20-in. cast iron pipe sewer, 300 lin. ft., $4; 8-in. cast iron, 800 lin. ft., 85 cts.; 50 manholes, $30 each; 40 lamp holes, $6 each; 17 flush tanks, $45 each.

Herkimer, N. Y.—F. K. Baxter, Ch. Engr., informs us that the contract for a separate system of sewers has been awarded to Beckwith & Quackenbush, at $24,814, the itemized prices being as follows: 20-in. pipe, $1.10 per lin. ft.; 18-in., 85 cts.; 15-in., 70 cts.; 12-in., 60 cts.; 10-in., 55 cts.; 8-in., 50 cts.; branches, 50 cts. each; excavation and embankment, 60 cts. per cu. yd.; manholes, $23 each; flush tanks, $28. $40 and $52 each for single, double and triple tanks, respectively; inspection holes, $3.50 each; slope wall, $2 per sq. yd. John H. Nelson bid $20,584; G. G. Harter, $47,139, and M. Sullivan, $42,252.

New London, Conn.—We are informed that bids were opened May 12 and a contract awarded at the following prices: 12-in. sewer, 7 ft. cut, at 84 cts. per lin. ft.; 10-in., 5.8 ft. cut, at 69 cts.; 10-in., 6.6 to 11.5 ft. cut, at 79 cts.; 8-in., 6 and 6.3 ft. cut, at 58 cts.; manholes, $9.85 per vert. ft.; rock excavation, $4.50 per cu. yd.; total, not including rock, $6,050.

LEAD.—Salt Lake City, Utah.—The following bids were received for 50 tons of pig lead: Utah & Montana Machinery Co., $80 per ton; David James, $87; Bogen Lead Co., $86; G. M. Scott & Co., $86.

PIPE.—Peabody, Mass.—The contract for about 3,000 ft. of water pipe has been awarded to Davis & Farnham, Waltham, at $26.64 and $28.14 per gross ton for 6 and 4-in. pipe, respectively.

South Bend, Ind.—The water board has awarded a contract for 800 or more tons of pipe to the Lake Shore Foundry, Cleveland, at $24.50 per ton.

PIPELAYING.—Peabody, Mass.—The contract for laying about 3,000 ft. of 6 and 4-in. water pipe has been awarded to D. B. Lord, at 39 and 35 cts. per lin. ft., respectively.

BRICK.—Holyoke, Mass.—The contract for building a sewer from Front St. to the Springfield road has been awarded to Baker, Cavanaugh & Co., at $12.95 per M. brick. Lynch Bros. bid $14 and Callahan & Curnane, Springfield, $17 per M.

BRICK PAVING.—Nashville, Tenn.—The following bids were received for paving Spruce St. with brick: J. B. Diver & Co., $1.52 per sq. yd.; Nashville Chemical Co., $1.38½; Southern Construction Co., Chattanooga, Tenn., $1.60; W. G. Bush & Co., Nashville, $1.25; Virginia Paving & Construction Co., $1.65; John Broderick, Nashville, $1.35.

BRICK AND GRANITE PAVING.—Omaha, Neb.—Contracts have been awarded as follows: J. E. Riley, paving with vitrified brick, $1.92, or $2.12 per sq. yd. for 5-yr. or 10-yr. guarantee, respectively; Sioux Falls granite, $2.35 to $2.65; Colorado sandstone, $2.25 and $2.35; Colorado or Berea sandstone curbing, 61 cts. per lin. ft.; Hugh Murphy, paving with Colorado sandstone, $1.90 per sq. yd.; Colorado sandstone curbing, 60 cts. per lin. ft.

TERMINAL STATION.—Brooklyn, N. Y.—The total bids received for the New York terminal station of the Brooklyn Bridge and a notice of the awarding of the contract to Levering & Garrigues, were noted in our issue of last week. The contract prices were as follows:

Riveted girders, steel	582,300	lbs. at	$0.034
Latticed girders, "	171,100	"	.036
Roof trusses, "	371,600	"	.038
Outer stairway stringers, steel	28,300	"	.06
Columns and struts, steel	161,500	"	.045
Rolled beams and channels, steel	431,000	"	.029
Purlins, steel	246,000	"	.039
Angle braces, plates, etc., steel	150,000	"	.04
Arch ties and wind-brace rods, wrought iron	43,000	"	.04
Wind-brace struts, wt. iron	30,000	"	.05
Gutters, moldings, risers, etc., cast iron	464,000	"	.075
Leaders, copper	1,900	lin. ft.	.50
Gutters along ventilator roof, copper	1,600	" "	1.00
Slat ventilators, copper	5,800	sq. ft.	.60
Cornices and architectural work, gal. iron	4,000	" "	.30
Roofing, tin	2,000	" "	.15
Stairway railings, iron	200	lin. ft.	3.00
Division railings, iron	100	" "	3.00
Snow guards, iron	1,100	" "	.60
Window guards, iron	1,600	sq. ft.	.30
Sales window railings, brass	30	lin "	5.10
Walls, brick	1,600	sq. "	1 10
" "	1,500	" "	.80
Floor arches, 8-in. thick, brick	41,000	" "	.42
" " 4-in. " "	10,000	" "	.25
Sills and platforms, granite	100	" "	3.50
Bed over floor arches, concrete	51,000	" "	.075
Bed over first floor and ramps, concrete	41,000	" "	.085
Bed for sidewalk, concrete	200	" "	.30
Floor surfaces, concrete	95,000	" "	.084
Fire proofing	200	" "	.75
Plastering	200	" "	.15
Roof, slate, incl. felt cov. and copper flashings	43,000	" "	.17
Wainscoting, incl. furring, Georgia pine	20,000	" "	.12
Partition, and inclosures, incl. frames, Georgia pine	1,000	" "	.25
Flooring, incl. nailing strips, Georgia pine	1,100	" "	.15
Sheathing, incl. purlin strips, Georgia pine	45,000	" "	.075
Stairway landings and treads, Georgia pine	1,200	" "	.30
Handrails, molded, ash	750	lin. "	.75
Handrails, cylindrical, ash	850	" "	.40
Ext. double swing-doors, incl. frames and trim	840	sq. "	1.00
Water closet doors, incl. frames and trim	250	" "	.45
Single interior doors, incl. frames and trim	40	" "	.75
Ext. swing-sashes, glazed, incl. frames and trim	5,000	" "	.70
Ext. stationary sash, incl. frames and trim	16,300	" "	.45
Int. hung sashes, incl. frames and trim	2,000	" "	.60
Int. sliding and stat'y sashes, incl. frames and trim	800	" "	.60
Hexagonal ticket booth	1		400.00
Square ticket booths	2		250.00
Rectangular ticket booth	1		300.00
Water closets, complete	14		95.00
Urinals, incl. marble or slate stalls, complete	7		75.00
Wash basins, complete	4		65.00
Slop-sinks complete	2		75 00
Drain and sewer pipes, 8-in. cast iron	1,500	lin. ft.	1.50
Leader pipes, 5-in., cast iron	400	" "	1.00
Water pipe, 2-in. wt. iron	300	" "	.60
Gas pipi g			450.00
Steam heating pipes and radiators			1,200.00
Trenches for drain, water and gas pipes	300	lin. ft.	.30
Roof lights, incl. metal sash and frames	24,100	sq. "	.44
Floor lights, incl. metal sash and frames	1,300	" "	1.75
Paints and painting, one coat	295,000	" "	.015
Taking down present station			10,500.00
Girders fitted to connecting girders	33		15.00
Arch angles riveted to girders	14		11 00
Girders lengthened	6		10.60
Girders spliced, with new cent. sect. inserted	12		30.00
Columns of 12-in. channels spliced	28		10.00
Columns of 9-in. channels spliced	47		10.90
Int. main roof trusses cut and spliced, with new sect	12		40 00
Wind brace rods lengthened or shortened	130		1.00
Erection of old wt. iron and steel parts	730,000	lbs.	.004
Erection of old cast iron parts	300,000	"	.015
Erection of old windows and frames	5,000	sq. ft.	.08
Erection of old partitions, wainscoting and cornices	2,000	" "	.12

MISCELLANEOUS.

DAM.—Albany, N. Y.—The governor has signed the bill appropriating $90,000 for repairing the state dam across the Mohawk River at Cohoes. The work will be done by contract under the direction of the state engineer.

DREDGING.—Galveston, Tex.—The Texas City Improvement Co. will receive bids until May 30 for dredging about 1,000,000 cu. yds. in Galveston Bay.

Brooklyn, N. Y.—The commissioner of city works will receive bids until May 22 for dredging at the foot of Main St.

STONE.—Cincinnati, O.—The following bids have been received by Maj. D. W. Lockwood, U. S. Engineer Office, for 2,652 cu. yds. of stone for rebuilding the lock near Green River, Ky.: Eigenmann & Hollerbach, Evansville, Ind., $25,068; P. H. Sweeney, Jeffersonville, Ind., $26,845.

DRAINAGE.—New Haven, Conn.—The park commission has directed that plans be prepared at once for the drainage of Beaver Ponds.

JAIL.—Hartwell, Ga.—The ordinary of Hart county will receive bids until May 27 for a county jail.

NATURAL GAS.—Butler, Pa.—We are informed that the Independent Natural Gas Co. has secured important territory and will extend its lines throughout the city, thus giving the citizens four competing lines.

STREET CLEANING.—Brooklyn, N. Y.—The contract for cleaning streets and removing ashes has been awarded to Robert Furey, the lowest bidder, at $29 per mile for cleaning 15,000 miles of streets annually for three years, and $190,000 for removing ashes for each of the first two years and $215,000 for the third year. The bids received for the work were published in our issue of March 23.

IMPROVEMENT BONDS.—Detroit, Mich.—The city controller will receive bids until May 29 for $100,000 each of boulevard and park improvement bonds.

INDUSTRIAL NOTES.

LOCOMOTIVES.—The Cooke Locomotive & Machine Co., Paterson, N. J., has an order of 14 ten-wheel passenger engines for the Southern Pacific; cylinders, 19 × 24 ins.; driving wheels, 5 ft. 3 ins. diameter; weight, 132,000 lbs., with 100,000 lbs. on the driving wheels.

The Rhode Island Locomotive Works, Providence, R. I., have turned out an eight-wheel express engine for the New York, Providence & Boston.

The Cincinnati, New Orleans & Texas Pacific will sell some of its old equipment and purchase new, the receiver having obtained the necessary order from the court.

The Cleveland, Cincinnati, Chicago & St. Louis has received the last of its new engines, making the additions to its equipment for the past year 30 freight engines, 20 switching engines and 10 passenger engines.

The Louisville, New Albany & Chicago has rebuilt three engines at its shops in New Albany, Ind.

CARS.—The American Car Co., Boise City, Va., has completed the first 15 of an order for 300 freight cars for the Chesapeake & Ohio.

The Missouri Car & Foundry Co., St. Louis, Mo., has an order for 1,000 box cars for the Cincinnati, New Orleans & Texas Pacific.

The Jones Vestibuled Sleeping Car Co., Denver, Colo., has elected officers for the year: Pres., H. W. Tabor; Gen. Man., W. E. Finch.

The Weaver-Getz Car Co. has been organized at Chicago, Ill., with a capital stock of $300,000, and will erect works at East Chicago.

RAILWAY FENCING.—The Page woven wire fence has been in experimental use on a number of railways for two or three years, and experience with it is said to be so satisfactory that it is now being purchased in carload lots by a number of important railways, including the Vandalia, West Shore, Michigan Central, and Lake Erie & Detroit River. The last named, a Canadian road, has nearly 100 miles in use. Several roads now under construction are also said to be purchasing this fence for use along the entire line. The advantages of the fence are its durability and the excellent manner in which it turns stock without injuring it, as barbed wire frequently does. Small stock, like pigs and lambs, cannot get through it, and it gives satisfaction to the farmers. The Michigan Central has had the fence in use for about 3½ years. We are informed that Mr. Dailey, of Detroit, who is in charge of bridge and fence construction on this road, reports examining a four mile stretch of Page fence put up last fall, and finding but a single wire broken in the whole line, this occurring where a splice had been made.

THE BUCYRUS STEAM SHOVEL & DREDGE CO. has removed its works and office from Bucyrus, O., to South Milwaukee, Wis., and hereafter all communications should be addressed to it at that place. The new plant was built in 1892, and is very extensive and complete. The ground comprises 15 acres, 13 of which are occupied by the main works. The two remaining acres, which are located on the harbor on the lake shore, will be used as a shipyard, and are connected with the main works by a belt line railway. The buildings are of steel, brick and glass, heated by the hot-blast ventilating system and lighted by electricity. The power is distributed from a central power-house by electricity to the various buildings, and two 150 HP. multipolar generators, driven by a cross compound Corliss engine, are employed. The machine shop and foundry are equipped with electric traveling cranes, with compressed air auxiliary cranes for the machine tools.

THE EDGE MOOR BRIDGE WORKS have removed their Chicago office to the Monadnock Block. Mr. Charles J. Morse, M. Am. Soc. C. E., is their representative.

THE HOLLY MFG. CO. has changed its offices from 45 Broadway to the Havemeyer Building, New York city.

THE CENTRAL IRON & STEEL CO., Brazil, Ind., is making an addition to the south side of main building, 35 × 225 ft. on the east; and another addition of 85 × 100 ft. They are also erecting a bolt and nut plant opposite the south side of the main building, 55 × 200 ft. Business for the year so far has been encouraging. The company have an exhibit of wooden tiles in the Manufactures Building, at the World's Columbian Exposition.

NEW COMPANIES.—Automatic Electric Railway Signal Co., New York, N. Y.; $3,000; Charles A. Senior, New York; Charles S. Lanehurst, Brooklyn, N. Y. Roy Artesian Well & Machine Co., Portland, Me.; $30,000; Pres., Charles A. Roy, East Providence, R. I.

NOTICE TO SEWER CONTRACTORS.

Ishpeming, Mich., May 6, 1893.

The Sewer Committee of the Common Council of the City of Ishpeming, Michigan, will receive proposals until 12 o'clock noon of Wednesday, May 31st, 1893, for building districts numbered 1 and 5 of the Ishpeming Sewer System.

Contractors may bid upon one or both districts; the proposal for each district must be enclosed in a separate envelope, sealed and properly endorsed.

Each proposal must be on a blank form furnished by the City, and be accompanied by a certified check, drawn and made payable to the order of the Treasurer of the City of Ishpeming, for the sum of five hundred dollars ($500); this check (or checks) to be forfeited by the successful bidder should he refuse to enter into a contract to do the work so awarded within five (5) days after receiving official notice of the award. Checks will be returned to unsuccessful bidders after the contracts are signed.

The engineer's estimate of the amount of work for each district, which will be used in comparing the proposals, is as follows:

Kind.	Dist. No. 1	Dis. No. 5.
30 inch brick sewer..		780 lin. ft.
24 inch brick sewer..	540 lin. ft	950 lin. ft.
18 inch pipe sewer...	135 lin. ft.	350 lin. ft.
15 inch pipe sewer...	1500 lin. ft.	1330 lin ft.
12 inch pipe sewer...	2882 lin. ft.	1750 lin. ft.
10 inch pipe sewer...	844 lin. ft.	555 lin. ft.
8 inch pipe sewer...	3305 lin. ft.	1715 lin. ft.
Flush tanks.....	14	6
Man holes.....	20	24
Lamp holes.....	11	10
Catch basins.....	60	55

Cast iron covers, ladder irons, curb boxes and flushing siphons will be furnished by the City.

The successful bidder will be required to furnish satisfactory bonds insuring the proper fulfillment of the conditions of his contract.

Plans can be examined and specifications, forms of proposal, contract and bonds obtained at the office of the Engineer in Charge, City Hall, in said City.

The committee reserves the right to reject any or all bids.

W. H. JOHNSTON,
HENRY ROUTHIER,
AUG. SWANSON,
Sewer Committee.

MELVILLE S. HAWKINS,
Engineer in Charge. 19-3t

CITY OF BRIDGEPORT, CONN.

TO BRIDGE CONTRACTORS.

Sealed proposals will be received by the Board of Public Works of said city, at room 10, City Hall, until 8 p. m. of Friday, May 26th, 1893, for furnishing all material and labor required in constructing and erecting the iron superstructure of new bridge across Pequonnock River, on the line of East Washington Ave. Plans and specifications may be consulted at office of, and all desired information may be obtained from, H. G. Scofield, City Engineer, at City Hall. Each proposal to be accompanied by a certified check for $500, payable to said Board, as a guarantee that if the bid is accepted a contract will be executed, and its performance properly secured. The Board reserves the right to reject any or all bids. By order of Board.

19-3t BERNARD KEATING, Clerk.

UTICA PIPE FOUNDRY CO.

CAST IRON PIPE AND SPECIALS FOR WATER AND GAS.

Also flanged Pipe and Fittings, Hydrants, Gates, Pig Lead, etc. CHAS. MILLAR & SON, Selling Agents, Utica, N. Y. Manufacturers of Lead Pipe and Plumbers' Materials. Wholesale Eastern Agents Akron Vitrified Sewer Pipe.

JOHN W. HARRISON, Pres. and Treas. THOS. HOWARD, Vice Pres.
F. B. NICHOLS, 2d Vice-Pres. E. H. QUKEN, Sec'y. P. MCARTHUR, Supt.

HOWARD-HARRISON IRON COMPANY,

MANUFACTURERS OF

CAST IRON PIPE

FOR WATER-WORKS, GAS WORKS, CULVERTS.
Pipe and Pump Connections. Flexible Joints. Heavy Loam Castings.
Works at BESSEMER, ALA. Offices at BESSEMER and ST. LOUIS.

ARTHUR KIRK & SON, PITTSBURGH, PA.

POWDER, DYNAMITE, ROCK DRILLS,
AIR COMPRESSORS, ROCK BREAKERS,
Safety Fuse, Electric Batteries, Miners' Squibs.

FOR Best Results USE THE WARREN FILTER,

—MANUFACTURED BY—

CUMBERLAND MFG. CO., Boston, Mass.

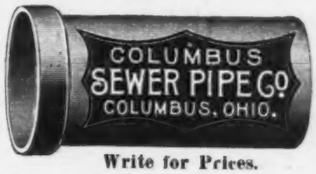
THE STANDARD CONSTRUCTION CO.,

GENERAL CONTRACTORS.

SEWER AND MASONRY BUILDING, STREET PAVING, ETC.

Main Office, Lewis Block, Pittsburg, Pa.

Smoothness of motion, absolute safety and high speed are among the good qualities possessed by OTIS ELEVATORS. They are built by Otis Brothers & Co., 38 Park Row, New York.



Write for Prices.

Any company contemplating the expenditure of a large amount in the establishment of a manufacturing industry, requiring the use of a thoroughly equipped Machine shop, Boiler shop, Foundry and Smith shop plant, well located on competing trunk lines on railroads and in a good labor market, is invited to address Stimson Williams & Co., Bryant Building, 55 Liberty street, New York city.

A CATALOGUE OF BOOKS for sale by Engineering News Publishing Co., Tribune Building, New York City, giving Prices and Terms, will be sent free on application.

U. S. ENGINEER OFFICE, Telephone Building, Detroit, Mich., April 20, 1893.—Sealed proposals for dredging Black River, at Port Huron, Michigan, will be received at this office until 2 p. m. on Wednesday, the 31st day of May, 1893, and then publicly opened. Specifications, blank forms and all available information will be furnished on application to this office. WILLIAM LUDLOW, Major of Engineers, Bvt. Lieut.-Col., U. S. A. 20-2t

PROPOSALS FOR SEWERS.

Sealed proposals will be received by the Commissioners of Sewers and Drainage of the Village of New Rochelle, Westchester Co., N. Y., until 6 o'clock p. m., May 22, 1893, for the construction of Sections No. 4 and No. 5 of the sewer system of said village in accordance with plans and specifications on file at the office of said Commissioners. Proposals for each section to be made separately.

Each proposal must be accompanied by a bond in the penal sum of one thousand dollars ($1,000), with two sureties, conditioned that same shall be forfeited to the Commissioners if the person or persons to whom the contract may be awarded shall neglect or refuse to execute the same within ten days after notification by the Commissioners that his or their proposal had been accepted.

The contractor will be required to furnish a bond with two or more sureties approved by the Commissioners in the penal sum of ten thousand dollars ($10,000), for section No. 4, and eight thousand dollars ($8,000) for section No. 5, conditioned and as security for the faithful performance of the contract and as indemnity for damages as provided by Section 8, Chapter 201, Laws of 1889.

The Commissioner of Sewers and Drainage reserve the right to reject any or all proposals and to award the contract to other than the lowest bidder or to re-advertise for proposals if they shall deem such course advantageous to the interests of the Village of New Rochelle.

Plans, specifications, form of proposal and further information can be obtained from J. K. Wilkes, C. E., at the office of the Commissioners, 284 Main street, New Rochelle, N. Y.

By order of the Commissioners.

JAMES W. TODD, Secretary.

Dated, New Rochelle, N. Y., May 1, 1893. 19-2t

PROPOSALS FOR WATER-WORKS.

Sealed proposals will be received at the office of the Water Commissioners of the City of Bradford, Pa., until 12 o'clock, noon, of the fifth (5) day of June, 1893, for furnishing the City of Bradford with the material, and for performing the labor necessary to the construction of a reservoir to hold 60 million gallons, and also the furnishing and laying of about seven miles of cast iron pipe, for an additional water supply for the City of Bradford, to be built in accordance with plans and specifications on file in the office of the Water Commissioners.

Separate bids will be required for the different divisions of the work.

For blank forms, specifications, or any other information, address the Superintendent of the Water Department or the City Engineer.

The City reserves the right to reject any or all bids.

S. D. HEFFNER,
Supt. Water Department.
F. W. DALRYMPLE,
City Engineer.
T. B. CLARK,
F. D. WOOD,
W. C. KENNEDY,
19-3t Water Commissioners.

FALCON'S BALL JOINT.

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WHY?

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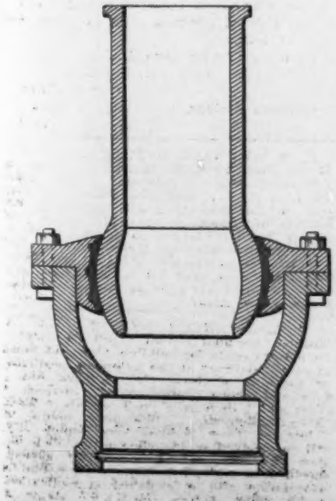
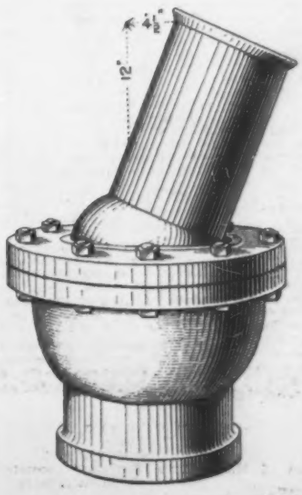
J. G. FALCON, Submarine Contractor and Diver,

EVANSTON, ILL.





COMMONWEALTH OF MASSACHUSETTS METROPOLITAN SEWERAGE COMMISSIONERS—NOTICE TO BUILDERS OF PUMPING ENGINES.—Sealed bids for the pumping plant for the Metropolitan Sewerage pumping station at East Boston, and sealed bids for the pumping plant for the Metropolitan sewerage station at Deer Island, will be received by the Board of Metropolitan Sewerage Commissioners at its office, 110 Boylston Street, Boston, Mass., until 12 o'clock m. of Saturday, May 27, 1893, and at that time will be publicly opened and read.

The Board will provide at each pumping station, an engine house, boiler house, chimney and masonry foundations for the pumps, and will furnish a fresh-water supply for the boilers up to the interior of the boiler house. The contractor's bid for each plant must be for furnishing, setting up, and completing, ready for use, two pumping engines (or sets of engines), four boilers, piping and all necessary appliances and fittings such as are to be found in pumping stations of the best class.

Each pumping engine must be capable of easily raising 70 cubic feet of sewage per second 19 feet vertically above the level of the sewage in its respective pump-well. Each of the engines must also be capable of raising to greater lifts up to 25 ft. quantities of sewage inversely proportional to such lifts.

Each engine must also be capable of pumping at as low a rate as 15 cubic feet per second, and at all rates between 15 and 70 cubic feet per second.

The foregoing capacities must be demonstrated by suitable trials.

Each bidder must state in his bid the duty he will guarantee for each engine in the duty trials outlined in the general specifications:

Table of Some Approximate Working and Trial Data, Etc.

	Deer Island.	East Boston.
Elevation of the surface of the sewage in the pump-well above datum....(Varies from	Feet. 94.0	Feet. 90.8
to	101.4	93.5
Elevation of the bottom of the pump well is assumed to be..	85.5	80.0
Elevation of the surface of the sewage in the discharge channel above datum.(Varies from	101.0	105.3
to	120.0	112.5
Least lift.....	6.0	14.5
Average lift.....	11.0	15.0
Ordinary maximum lift.....	18.6	19.0
Lift during duty trial at rate of 70 cu. ft. per sec.....	11.0	15.0
Lift during capacity trial at rate of 70 cu. ft. per sec...	19.0	19.0
The elevation of the boiler house floor should be not lower than.....	116.5	116.5

The elevations mentioned above are referred to a datum about 100.64 feet below mean low water of Boston Harbor.

The contractors must provide at each station four steam boilers of such capacity that any three of them can easily supply the necessary steam for the two engines when discharging together 140 cubic feet per second with a lift of 19 feet.

Plans will be furnished by the Board showing the position of the engine houses and the in-coming and out-going sewers at East Boston and Deer Island.

The first pumping engine at each station, and at least two boilers at each station, must be set up, ready to run, before May 31, 1894; the remaining engine, boilers and other appliances before Aug. 31, 1894. A third pumping engine and additional boilers will probably be called for at each station within a few months thereafter, and a fourth engine and additional boilers may be needed in the future. The third and fourth engines and their boilers are not now to be bid for. The arrangement of the plant, however, must be such as will not interfere with the above named extension.

The design of the pumping engines may be of any form which will fulfill the required conditions of the general specifications.

Each bid must be accompanied by drawings showing clearly the size and arrangement of the steam cylinders, pumps, boilers and all other parts of the mechanism and must also show the necessary details for the engine foundations, which are to be provided by the Board.

The specifications, which must also accompany the bid, must give the kind and the quality of the materials of which the various parts are to be composed, the size and the strength of the principal working parts, and the manner in which they are to be constructed, so as to furnish a clear understanding of all points regarding the workmanship, strength, durability, general efficiency of and space occupied by the whole mechanism and plant.

Each bid must be inclosed in a sealed envelope indorsed "Proposal for Pumping Plant for the Metropolitan Sewerage Pumping Station at East Boston" or "Proposal for the Pumping Plant for the Metropolitan Sewerage Pumping Station at Deer Island," and be delivered to the Board or to its clerk.

Each bid must be made on one of the blank forms furnished by the Board, and must be accompanied by a properly certified check for the sum of $1,000, the latter to be returned unless forfeited by the abandoning of the proposal.

The Board reserves the right to reject any and all bids.

Plans, blank forms, general specifications and further information may be obtained at this office.

HOSEA KINGMAN,
TILLY HAYNES,
HARVEY N. COLLISON,
Board of Metropolitan Sewerage Commissioners of Massachusetts.
HOWARD A. CARSON,
Chief Engineer. 18-20

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSIONERS.—NOTICE TO BUILDERS OF PUMPING ENGINES.

Sealed bids for the pumping plant for the pumping station at CHARLESTOWN will be received by the Board of Metropolitan Sewerage Commissioners at its office, 110 Boylston Street, Boston, Mass., until 12 o'clock m. of Saturday, July 1, 1893, and at that time will be publicly opened and read.

The Board will provide an engine-house, boiler-house, chimney and masonry foundations for the pumps, and will furnish a fresh water supply for the boilers up to the interior of the boiler-house. The contractor's bid must be for furnishing, setting up and completing, ready for use, two pumping engines (or sets of engines), two boilers, piping, and all necessary appliances and fittings, such as are to be found in pumping stations of the best class.

Each pumping engine must be capable of easily raising 35 cubic feet of sewage per second 11 feet vertically above the level of the sewage in its respective pump well. Each of the engines must also be capable of raising to greater lifts up to 30 feet, quantities of sewage inversely proportional to such lifts.

The contractors must provide at the station two steam boilers of such capacity that either of them can easily supply the necessary steam for the two engines when discharging together 70 cubic feet per second, with a lift of 11 feet.

The design of the pumping engines may be of any form which will fulfil the conditions named in the general specifications.

Each bid must be made on one of the blank forms furnished by the Board, and must be accompanied by a properly certified check for the sum of $1,000, the latter to be returned unless forfeited by abandonment of the proposal.

The Board reserves the right to reject any and all bids.

Plans, blank forms, general specifications and further information may be obtained at this office.

HOSEA KINGMAN,
TILLY HAYNES,
HARVEY N. COLLISON,
Board of Metropolitan Sewerage Commissioners of Massachusetts.
HOWARD A. CARSON,
19-8t Chief Engineer.

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSIONERS.—NOTICE TO CONTRACTORS.

Sealed bids for building Section 30 of the Metropolitan Sewerage System in Cambridge, and Section 44 in Winchester, in accordance with the form of contract and specifications to be furnished by the Board of Metropolitan Sewerage Commissioners, will be received by said Board at its office, 110 Boylston Street, next to Old Public Library, Boston, Mass., until 12 o'clock m. of Saturday, June 3, 1893.

No bid will be received unless accompanied by a certified check for the sum of $1,000.

All bids must be made upon the blank forms furnished by the Board.

Some other particulars are estimated to be as follows:

Sec. 30.—Length, 7,020 ft. Av. cut to 10 ins. below invert, 14.5 ft. Maximum outside width of masonry, 68 ins.

Sec. 44.—Length, 5,600 ft. Av. cut to 10 ins. below invert, 14.5 ft. Maximum outside width of masonry, 48 ins.

Plans can be seen and specifications and forms of contract can be obtained at the above office.

Each bidder is required to make a statement indicating what sewer and similar work he has done, and to give references that will enable the Board to judge of his business standing.

The Board reserves the right to reject any and all bids.

HOSEA KINGMAN,
TILLY HAYNES,
HARVEY N. COLLISON.
Board of Metropolitan Sewerage Commissioners of Massachusetts.
HOWARD A. CARSON,
Chief Engineer. 20-2t

U. S. ENGINEER OFFICE, CHARLESTON, S. C., April 15, 1893.—Notice is hereby given to all parties interested in the wreck of the schooner "Kate V. Aitken," in Swash Channel, Charleston Harbor, S. C., or in the cargo, if any, of said craft, that if same are not removed within 30 days it is the purpose of the Hon. the Secretary of War of the United States to treat said wreck and cargo as abandoned and derelict, and cause their removal, as prescribed by Sec. 4, Act of Congress, approved June 14, 1880. Sealed proposals for removing this wreck will be received at this office until 12 noon of May 15, 1893, and then publicly opened. Specifications, blank forms and all available information will be furnished on application to this office. 16-4t

PROPOSALS FOR FREE BRIDGE.

Notice is hereby given that the undersigned will, on June 5, 1893, at the office of the County Judge of Pulaski County, receive plans and working specifications for building a bridge across the Arkansas River at Broadway Street, in the city of Little Rock, reserving the right to reject any and all plans and specifications. No plans and specifications will be paid for unless finally accepted.

This 27th day of April, 1893.

W. A. COMPTON,
County Judge.
GEO. L. BASHAM,
W. B. WORTHEN,
18-3t Commissioners.

PROPOSALS FOR WATER-WORKS, HILLSBORO, OHIO.

Proposals will be received by the Village of Hillsboro, Ohio, up to 12 o'clock, noon, of the 14th of June, 1893, for a complete system of water-works, approximately as follows:

1st Division.—A system of not less than twelve 8-inch wells, approximately 50 feet deep, properly connected.

2d Division.—Brick building, with stone foundation, for pumping station.

3d Division.—Two compound, duplex pumps of a capacity each of 1,000,000 gallons per twenty-four hours, with boilers and all appurtenances.

4th Division.—One stand-pipe, 15 feet in diameter, 160 feet high; also foundation for same.

5th Division.—Pipe distribution system, consisting of approximately 9.05 miles of pipe, varying from 10 inches to 4 inches in diameter, with valves, special casting and 68 fire hydrants.

Bids will be received upon the whole or any division of the work.

Each bid must be made upon a blank form furnished for the purpose, and must be accompanied by cash, draft or certified check for an amount equal to $100, plus 1¼ per cent. of the amount of the bid, and made payable to the order of the Village Clerk.

Bids to be addressed to the Village Clerk of Hillsboro, Ohio, and marked, "Proposal for Water-Works."

Plans, specifications and form of proposal are on file at the office of the Consulting Engineer, and also in Hillsboro, Ohio, at the office of the Village Clerk, to whom all communications should be addressed.

The right to reject any or all bids is specially reserved.

N. H. AYRES,
H. D. DAVIS, Village Clerk.
Mayor.
EDWARD FLAD, Consulting Engineer, 118 Laclede Building, St. Louis, Mo. 19-3t

STREET PAVING—NOTICE TO CONTRACTORS.

Sealed proposals will be received by the City Clerk of Lima, Ohio, by R. H. Gamble, Assistant Engineer in charge of street paving, until 12 o'clock noon (central standard time) of Thursday, May 25th, 1893, and opened immediately thereafter, for the paving of the Public Square, in the city of Lima, Ohio, with vitrified paving brick, together with all curbing, catch basins, drainage, etc., incident thereto, in accordance with plans and specifications on file in the office of the Engineer. All bids which are not made on forms furnished by the Engineer, or which are submitted on any other conditions than those stipulated in said form or specifications, will be rejected as irregular and informal. No bid will be considered unless accompanied by a certified check (payable to the City Clerk), or legal currency to the amount of five hundred (500) dollars, or by the City Clerk's receipt for the same. All such deposits will be returned to the unsuccessful bidders within ten (10) days from the award of contract. If the successful bidder shall refuse or neglect to execute a proper contract and furnish a bond acceptable to the City Council within ten (10) days from the time said contract shall have been awarded to him, the said certified check or currency shall be forfeited to and retained by the said city of Lima, Ohio, as liquidated damages for such refusal or neglect, otherwise the said deposit will be returned to him.

Samples of brick and stone and samples or models of iron sewer inlets must be submitted with bid.

The following are the approximate quantities of work:

12,633 square yards of brick pavement.
1,400 lineal feet of six (6) inch curbing.
8 circular curb corners.
6 catch basins.
12 iron gutter crossings.

Together with the necessary sub-drainage, etc.

The City reserves the right to reject any or all bids, before or after opening the same, which may be accompanied by samples of brick which in the opinion of the Engineer will not meet the requirements of the specifications; and to accept any proposal which may be deemed most proper.

Specifications, forms of proposal and other information may be had on application to R. H. Gamble, Assistant Engineer, Lima, Ohio.

By order of Council.
Lima, Ohio, April 25, 1893.
D. E. JONES,
President of Council.
J. B. DOUGLASS, City Clerk. 18-3t

NOTICE TO SEWER CONTRACTORS.

Sealed proposals will be received at the Town Clerk's office, East Providence, R. I., until Tuesday, May 16, at 2 p. m., for the construction of 1,800 feet of 36-inch to 20-inch brick sewer, and 1,600 feet of 15-inch to 6-inch pipe sewer, with manholes, catch-basins, and connections. Plans and specifications can be seen at the office of the Engineer, No. 1 Ray's Block, East Providence. The Town Council reserves the right to reject any and all bids.

GEORGE F. HUNTER, Town Clerk.
W. M. DEXTER, Engr. 18-2t

PROPOSALS FOR WATER-WORKS CONSTRUCTION.

Sealed proposals will be received by the city of Highland Park, Ill., until 8 p. m., Tuesday, May 23, 1893, for furnishing all material and completing a water-works system, including the following items:

A brick pumping station, 60 ft. x 28 ft., with 90-foot stack.

A stand-pipe, 16 feet in diameter by 100 feet high.

2,000 feet of 16-inch cast iron, submerged intake pipe, inlet crib and settling well.

2 pumping engines, 1,500,000 gallons capacity each.

2 horizontal tubular boilers, 60-inch x 16-foot, with connections.

7,500 feet of 12-inch, 6,000 feet of 10-inch, 8,250 feet of 8-inch, and 2,680 feet of 6-inch cast iron water pipe, with hydrants and valves.

Bids may include the entire work or parts thereof, and must be made on the blanks furnished by the city., and be accompanied by a certified check for an amount within $100 of 3% of the total amount of work bid for.

Plans and specifications may be examined, and blank proposals obtained at the office of H. L. Bowen, City Engineer, Highland Park, and at the office of the Chief Engineer, W. S. Shields, Room 1407 Title & Trust Bldg., Chicago.

The city reserves the right to reject any and all bids. Payments will be made in special assessment warrants, and the contract, if awarded, will be subject to the confirmation of the assessment in June.

J. A. WOODWORTH,
A. W. FLETCHER, City Clerk.
Mayor. 19-2t

PROPOSALS FOR CAST IRON WATER PIPE AND WATER BONDS.

Sealed proposals will be received at the City Clerk's office, Colorado Springs, Colo., until 8 o'clock p. m., May 29th, 1893, for furnishing the following approximate quantities of materials:

240 lin. ft. of 14-inch cast iron pipe.
7,160 " " 12-inch " "
6,890 " " 10-inch " "
13,300 lbs. of cast iron special castings.
48 valves (6, 8, 10, 12 and 14 inch).

Bidders will state price per ton (2,000 lbs.) for pipe and castings, and price per valve, delivered f. o. b. car, Colorado Springs; also f. o. b. car at factory. Delivery of pipe and specials must begin in ten days, and be wholly completed within sixty days from date of execution of contract. The successful bidder will be required to execute contract, with the required surety, in the sum of $4,000, in five days after notice that contract has been awarded to him.

Blank forms of contract, specification, bond and proposals can be obtained at the City Engineer's office.

Also, at same time and place as above, sealed bids for water-works bonds will be received as follows: $82,000 refunding water-works bonds running 50 (optional at 40) years, bearing four per cent. interest, and $35,000 water-works construction bonds running 15 (optional at 10) years, bearing five per cent. interest. Proposals should be indorsed, "Bids for Water Pipe" or "Bids for Water Bonds," and addressed to C. E. Smith, City Clerk, Colorado Springs, Colo.

City Council reserves right to reject any and all bids.

By order of City Council.
H. I. REID,
City Engineer.
Colorado Springs, Colo., May 6, 1893.
19-3t

U. S. ENGINEER OFFICE, NEWPORT, R. I., April 14, 1893.—Sealed proposals, in triplicate, will be received at this office until 11 a. m., May 23d, 1893, and then opened, for furnishing and delivering 900 barrels of American hydraulic cement; of which 500 barrels are to be delivered at Fort Adams, Newport Harbor, R. I., and 400 barrels at Dutch Island, Narragansett Bay, R. I. For all information apply to W. H. BIXBY, Captain, Corps of Engineers, U. S. Army. 17-4t

U. S. ENGINEER OFFICE, CUSTOM House, Cincinnati, Ohio, April 29, 1893.—Sealed proposals for building dikes and dams in the Ohio River at the following locations, or any one of them, viz.: 4 dikes and 1 dam and shore protection at Clusters, 2 dikes and 1 dam at French Island, 2 dikes near Scuffletown, 1 dike near mouth of Tidewater River, 2 dikes near Mound City, will be received at this office until 2:30 p. m., May 29, 1893, and then publicly opened. Specifications, blank forms, and all available information will be furnished on application to this office. AMOS STICKNEY, Major of Engineers, U. S. A. 19-4t